COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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October, 1949

OCT 28 1949

General view of B. C. Cobb Plant. For description see page 40

B. C. Cobb Plant of The Consumers Power Co. ▶

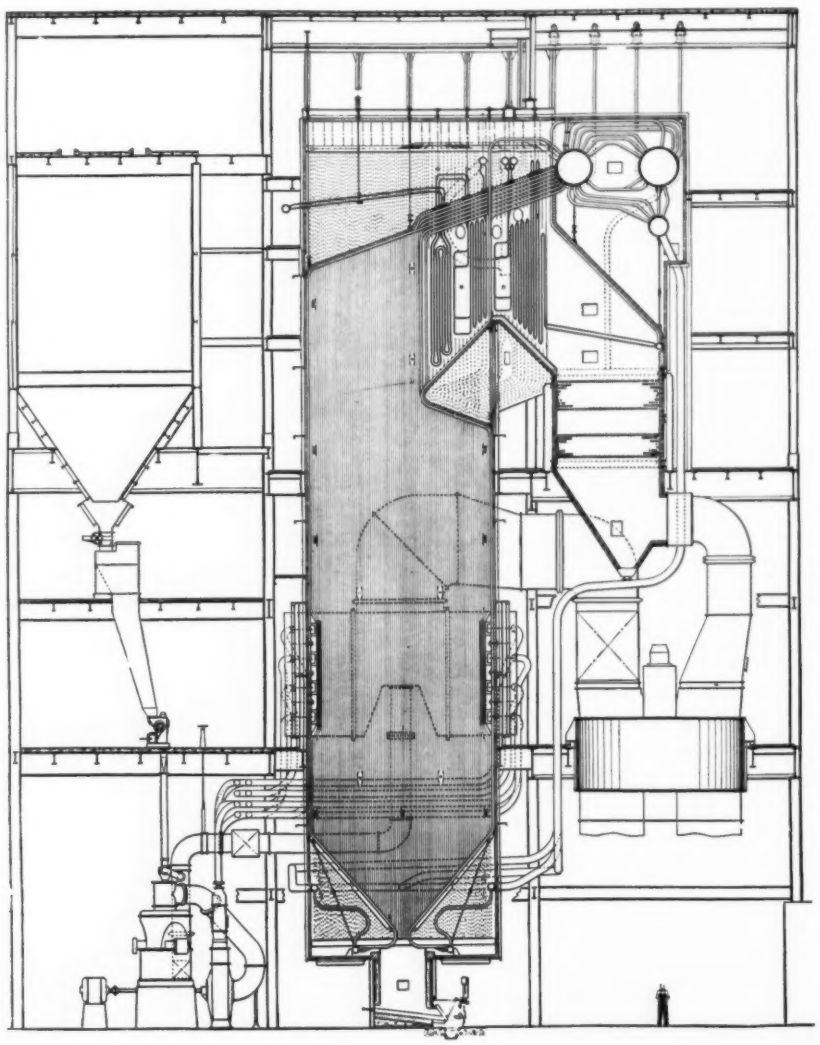
Operation and Maintenance of Steam Generating Equipment ▶

Flue Gas Temperature Measurement at Low Velocities ▶

Recent C-E Steam Generating Units for Utilities

PLANT YATES

GEORGIA POWER COMPANY



THE C-E Unit illustrated here, one of two duplicates, is now in process of fabrication for Plant Yates of the Georgia Power Company, Whitesburg, Georgia.

It is designed to produce, at maximum continuous capacity, 975,000 lb of steam per hr at 1325 psi and 950 F.

The unit is of the 3-drum type with 3-stage superheater and economizer surface in the rear pass. Regenerative air heaters follow the economizer surface.

The furnace is completely water cooled, using plain tubes on close centers, and is of the basket bottom type, discharging to a sluicing hopper.

Pulverized coal firing is employed, using bowl mills and vertically-adjustable, tangential burners. Natural gas will also be used as an alternate fuel or in combination.

This unit and its duplicate will each serve 100,000-kw turbine-generators comprising the first section of a completely new station. B-311

C-E

Combustion Engineering–Superheater, Inc.

A Merger of COMBUSTION ENGINEERING COMPANY, INC. and THE SUPERHEATER COMPANY

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COMBUSTION

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Vol. 21 **No. 4**

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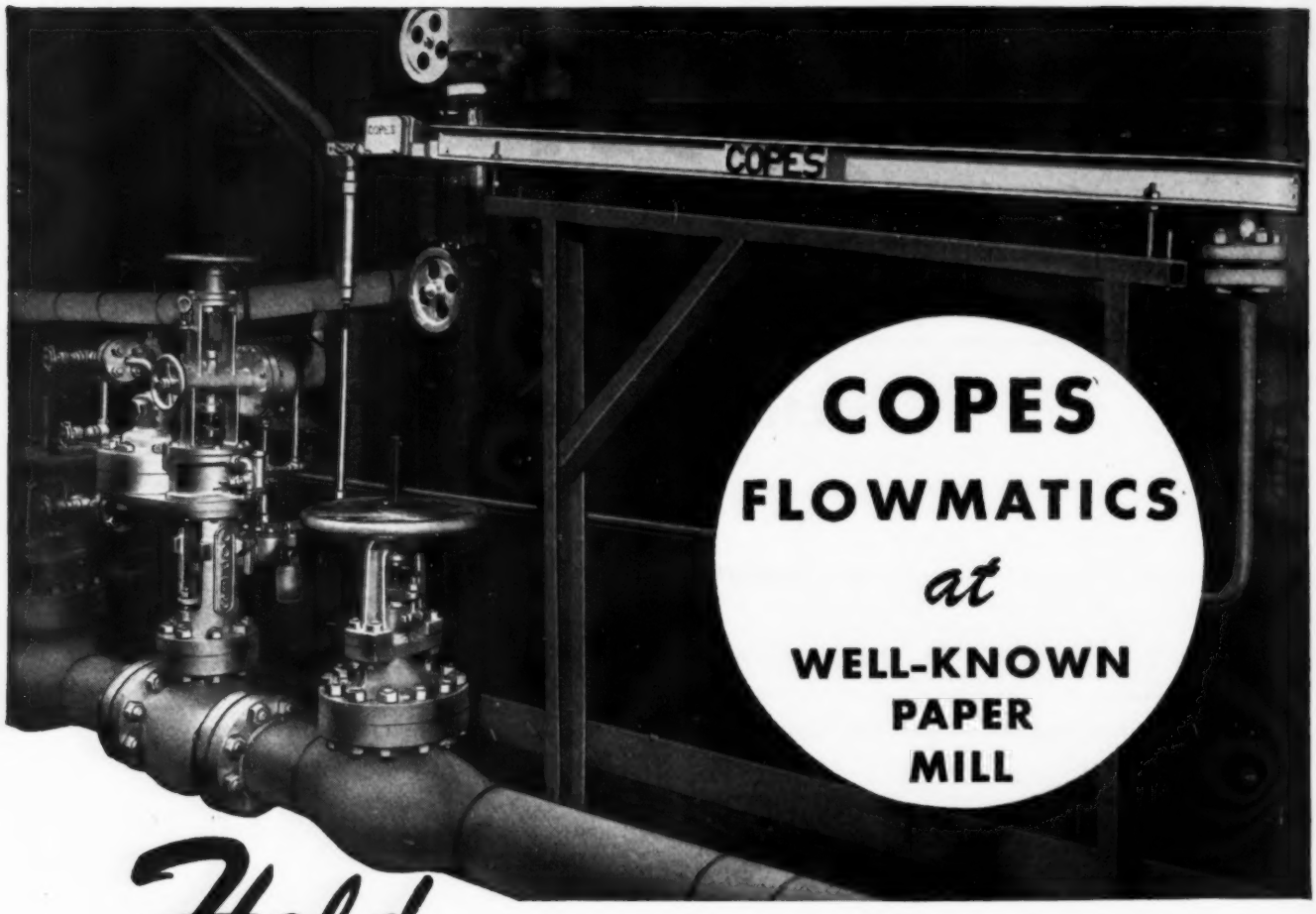

Hold CLOSE WATER LEVEL on fast-steaming boilers taking rapid swings

Here is one of two COPES Flowmatics serving 810-psi, 825-F C-E Type VU boilers in one of New York State's most modern paper mills. Rated at 110,000 pounds per hour, each boiler is subject to a sharp load change every three minutes. Despite this severe service, drum water level is held within plus-or-minus one inch.

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Editorials

A Challenge to Engineering Thinking

Talks before two recent gatherings of engineers have sounded a warning as to where we may be headed as a nation under the guise of security.

Speaking at Youngstown on September 27, James M. Todd, president of the American Society of Mechanical Engineers, cautioned that millions of Americans must change their fundamental attitude toward life if a welfare state in this country is to be prevented. Speaking again two days later at the Fall Meeting of the Society in Erie, Mr. Todd observed that the economic picture of the United States and of the world presents a challenge to the engineering profession and, further, "that even though the ends may appear justifiable, we must consider this country's burdens in its program of world help, lest victory by bankruptcy be the Machiavellian aim of our enemies."

At the same meeting, Dr. K. T. Glennan, president of Case Institute of Technology, deplored the fact that today's younger generation, and particularly those being graduated from colleges, are placing undue emphasis on security. This is very definitely imposing restrictions on the selection of careers. He attributed such an attitude to the fact that their impressionable years had been spent in a period of governmental paternalism, devastating war and now an uncertain peace. The danger, he said, in placing such high values on material security is that it is the bait that has drawn nations into traps of dictators.

A third speaker at this meeting, Senator Edward Martin of Pennsylvania, warned his audience that final control is held by the level of government which furnishes the money; and that today, through grants-in-aid, an ever-increasing proportion of state expenditures comes from taxes collected by the Federal Government. Although Americans will never knowingly or willingly surrender their freedom for the iron rule of the so-called welfare state, he cautioned that step-by-step we appear to be advancing in that direction.

Here, under the auspices of one of the four founder engineering societies, we have the almost coincident opinions of three individuals representing diverse fields—an outstanding engineer, a prominent educator and a well-known legislator.

Surely, technology, which has played the major role in achieving our present high standard of living and which contributed so much to the winning of two wars, has a vital stake in the maintenance of unfettered opportunities for further advancement; and the present trend holds a challenge to the thinking of all engineers, regardless of political affiliations.

Future of Atomic Power Engineering

In considering the future of atomic power engineering it may be revealing to contrast that field with the present state of steam power engineering. A little reflection will indicate the gradual, sometimes relatively unnoticed evolution which has taken place in the steam power plant since the days of James Watt. Not one but countless thousands of improvements, inventions and developments have gone into the modern power plant. If all of this progress were assumed to have taken place in less than four years and to have been initiated by the dramatic news of the atomic bombing of Hiroshima, then steam power plant engineering would find itself in a situation somewhat analogous to that of today's atomic power engineering.

At present, atomic power engineering is in the laboratory and development stages, but it is not too soon to consider future requirements for atomic power engineering personnel. While these needs will to some extent parallel those of the existing power industry, the young engineer expecting to enter this type of work should have training in nuclear physics and chemistry as well as in a conventional engineering field. When atomic power engineering passes through the development era and on to the operating stage, there will be additional need for managing engineers, operating engineers, maintenance engineers, safety engineers, and teachers of atomic power engineering.

That time may not be as far distant as seemed likely two or three years ago, for with most of its earlier organizational and administrative problems settled, the Atomic Energy Commission is now in a better position to direct closer attention to practical problems of power development.

In the long run the work of the atomic power engineer will not differ essentially from that of his colleagues in the established engineering specialties of today. For young persons contemplating the atomic power field it would appear to be wise counsel to emphasize that engineering work rarely carries with it the glamour that is associated with over-sensationalized publicity of new technological developments. Dramatic as was the news of Hiroshima, and unbelievably rapid as were the scientific and engineering efforts that led up to that event, the sound approach to the future of atomic power engineering is to consider it in terms of a series of small but related developments which will ultimately lead to the practical realization of harnessing atomic power. In this manner atomic power engineering can achieve a recognized position within the engineering profession of the future.

B. C. COBB PLANT of the Consumers Power Company

Present capacity of this 950-psi, 900-F, pulverized-coal-fired installation is 120,000 kw in two units. A third 60,000-kw unit is scheduled to go in service next year. The first six months' operation has shown a net station heat rate of 11,138 Btu per kwhr. Based on three units, the initial cost figures $128 per kw.

By CHARLES D. BIRGET

General Engineering Department
The Commonwealth & Southern Corporation

THE B. C. Cobb Plant of the Consumers Power Company, named in honor of B. C. Cobb, one of the organizers of this company and its active chief executive from 1915 to 1934, is located on the outskirts of Muskegon, Michigan. The present installation consists of two units with a nameplate rating of 60,000 kw each. A third is now under construction and, upon its completion, will add another 60,000 kw. Design is based on an ultimate capacity of 360,000 kw. Construction on the first two units was started in August 1946, with the first unit going into operation October 24, 1948, and the second December 23, 1948. The third unit is scheduled to go into service in 1950.

Site and Building Design

The site consists of 352 acres located at the east end of Muskegon Lake, at the mouth of the Muskegon River, which makes available ample circulating water for the ultimate plant, and, with the construction of dock facilities, allows the plant to be supplied with water-borne coal at appreciable saving.

The main building houses the steam generators and turbine-generators and their auxiliary equipment. There is an office section at the front of the plant which includes administrative offices, general offices, assembly rooms, the chemical laboratory, and the maintenance shop. This building rests on a base slab 7 ft 3 in. thick of which 4 ft 9 in. is reinforced concrete. The reinforced section carries the load of the columns and walls together with the equipment located on the basement floor while the additional $2^1/_2$ ft is a lean concrete which provides space for electrical conduits that would normally be embedded in the reinforced concrete base slab. This type of design permits construction to proceed without delay following the lower section of the base slab.

The reinforced concrete base slab is supported on 24-in. OD open-end pipe piles, filled with concrete, which rest on sandstone at a depth varying from 170 to 190 ft below the bottom of the base slab. A total of 191 piles carries the load of the first two units and the screen house. This piling was driven by the Raymond Concrete Pile Company. Intake ducts span the distance from the screen house to the plant in the form of a reinforced concrete beam. With this piling arrangement each pile carries between 436,000 lb and 606,000 lb. The discharge duct and the coal-handling system are supported by timber piling driven to a resistance of 20 tons. Borings indicated that the earth between the top of the ground and the sandstone rock, approximately 200 ft below, consisted of muck, gumbo, sand, silt, and decayed vegetable matter which have very little supporting qualities but did give some lateral stability. It is believed that this is the first structure of its kind to be placed on piling of this length. The relatively expensive foundations necessary at this site near the load center were amply justified when compared with the costs of longer transmission lines and their upkeep and line losses at other possible sites considered.

Steam Generation

The steam generators for the three units are the Combustion Engineering–Superheater, Inc. three-drum, bent-tube, type with a steam washer in the rear steam drum. Each is designed to produce 600,000 lb of steam per hour at 950 psig, 900 F total temperature, and, with its auxiliaries, is entirely contained within the boiler room.

The furnace is fired tangentially by C-E Type TV (tilting type) pulverized coal burners designed to permit adjustment of the firing zone above and below the neutral position to control temperature of the furnace exit gases and, in conjunction with bypass dampers, the temperature of the steam. A fuel oil system has been installed for lighting off.

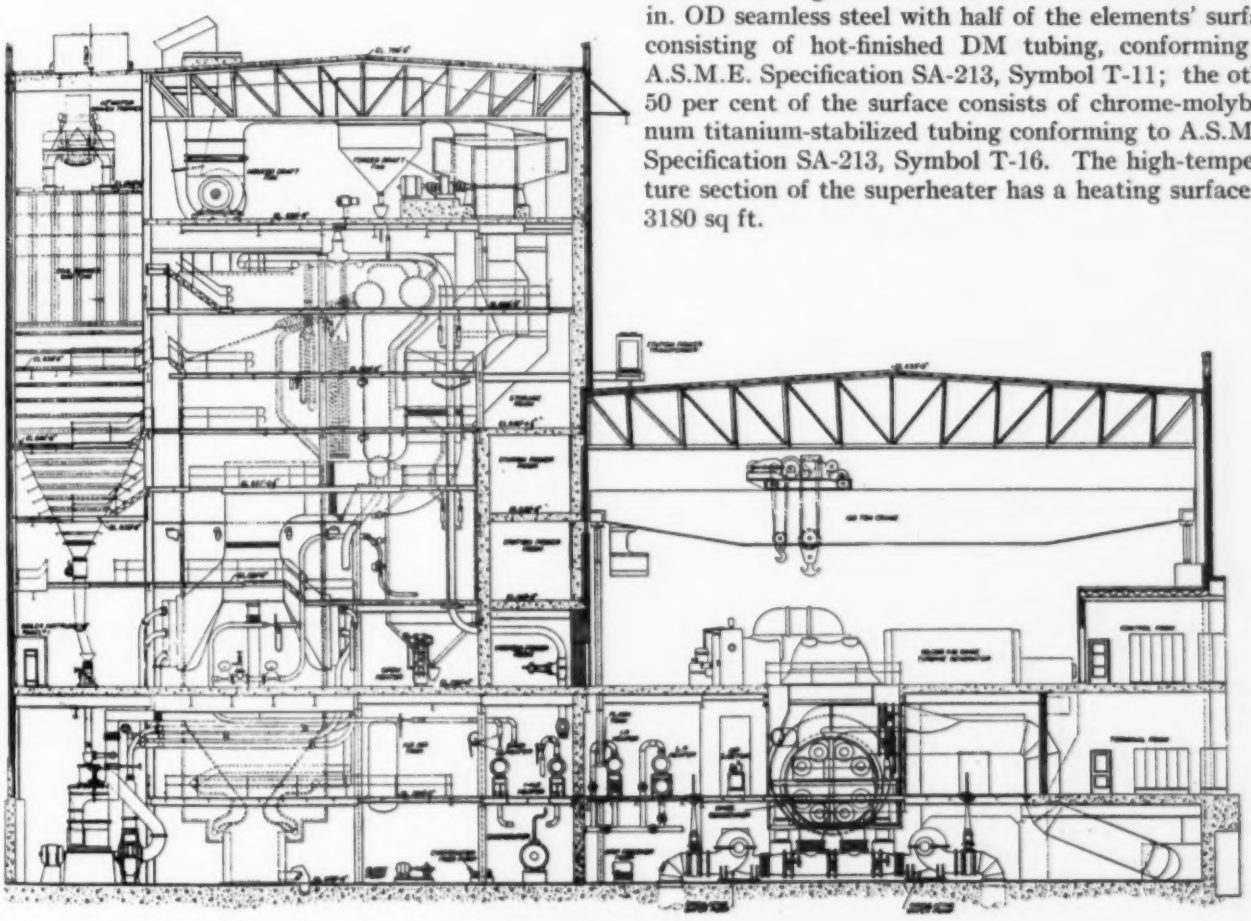
The coal pulverizing system consists of three independent feeders; three C-E Raymond bowl mills with direct-connected exhausters driven at 900 rpm by a 300-hp, 2300-volt, 3-phase Westinghouse induction motor; fuel distributors; and transport piping to the burners. Each feeder is driven by a constant-speed motor through a Raymond vari-stroke speed-changer and a clutch feeder drive. Coal flows from the Gunite-lined steel bunkers of 800 tons capacity through hoppers arranged so that each hopper supplies one feeder. Two 24 × 24-in. coal valves, supplied by the Henry Pratt Company, are located side by side to provide dual outlets on each hopper. Coal flows from the outlet of these valves in a specially designed chute to the individual feeder supplied by that hopper. This arrangement has been found of material help in reducing coal sticking in the bunkers. From the feeders, located on the operating floor, coal is fed directly to the pulverizers which are arranged for center feeding. All piping from the feeders to the pulverizers is straight in order to reduce the likelihood of stoppage. The fuel

distributors, which consist of three large and six small cast-iron riffle type units, are mounted on the exhausters. From the distributors the fuel is transported to the burners in 11-in. pipes.

Temperature of the coal-air mixture leaving the pulverizer is controlled by positioning the hot-air damper on the inlet side of the pulverizer. A weight-loaded damper located between the hot-air damper and the mill is positioned by difference in pressure across the damper, and a coal-air temperature recorder is provided on the boiler panel for use in regulating this temperature. A relay prevents overloading the pulverizer motor, by stopping feed until the load drops to 20 per cent below tripping value. A centrifugal switch on the pulverizer motor shaft is set to trip out the pulverizer should its speed drop, due to low voltage, to the point where the burner flames become unstable and thus prevent the pulverizer from starting again until the oil torches are lighted.

The furnace, which is of the hopper-bottom type, has a gross volume of approximately 41,000 cu ft and was designed for a heat release of 19,000 Btu per cu ft per hr. It is completely water cooled on front, sides, rear and top by 3-in. plain seamless steel tubing spaced on $3^1/_8$-in. centers. The upper front drum is 54 in. in diameter and assists in primary separation. The upper rear drum, 60 in. in diameter, contains the steam washer and screen drier which is designed to hold the carryover to 1 ppm when boiler water concentration does not exceed 1500 ppm and entering feedwater does not exceed 50 ppm.

The superheater is of the continuous convection, pendant, bare-tube type, divided into two sections. The low-temperature section, located nearest the boiler and connected between the inlet and intermediate headers, is made up of 102 six-loop elements. The first nine inlet tubes are of low-carbon seamless steel tubing conforming to A.S.M.E. Specification SA-192. The last three outlet tubes are of carbon molybdenum steel tubing conforming to A.S.M.E. Specification SA-209, Grade T-1B. This section of the superheater has a heating surface of approximately 13,120 sq ft. The high-temperature section located nearest the furnace and connected between the intermediate and outlet headers, consists of 102 two-loop elements arranged in 51 assemblies. The tubes are of $2^1/_8$ in. OD seamless steel with half of the elements' surface consisting of hot-finished DM tubing, conforming to A.S.M.E. Specification SA-213, Symbol T-11; the other 50 per cent of the surface consists of chrome-molybdenum titanium-stabilized tubing conforming to A.S.M.E. Specification SA-213, Symbol T-16. The high-temperature section of the superheater has a heating surface of 3180 sq ft.

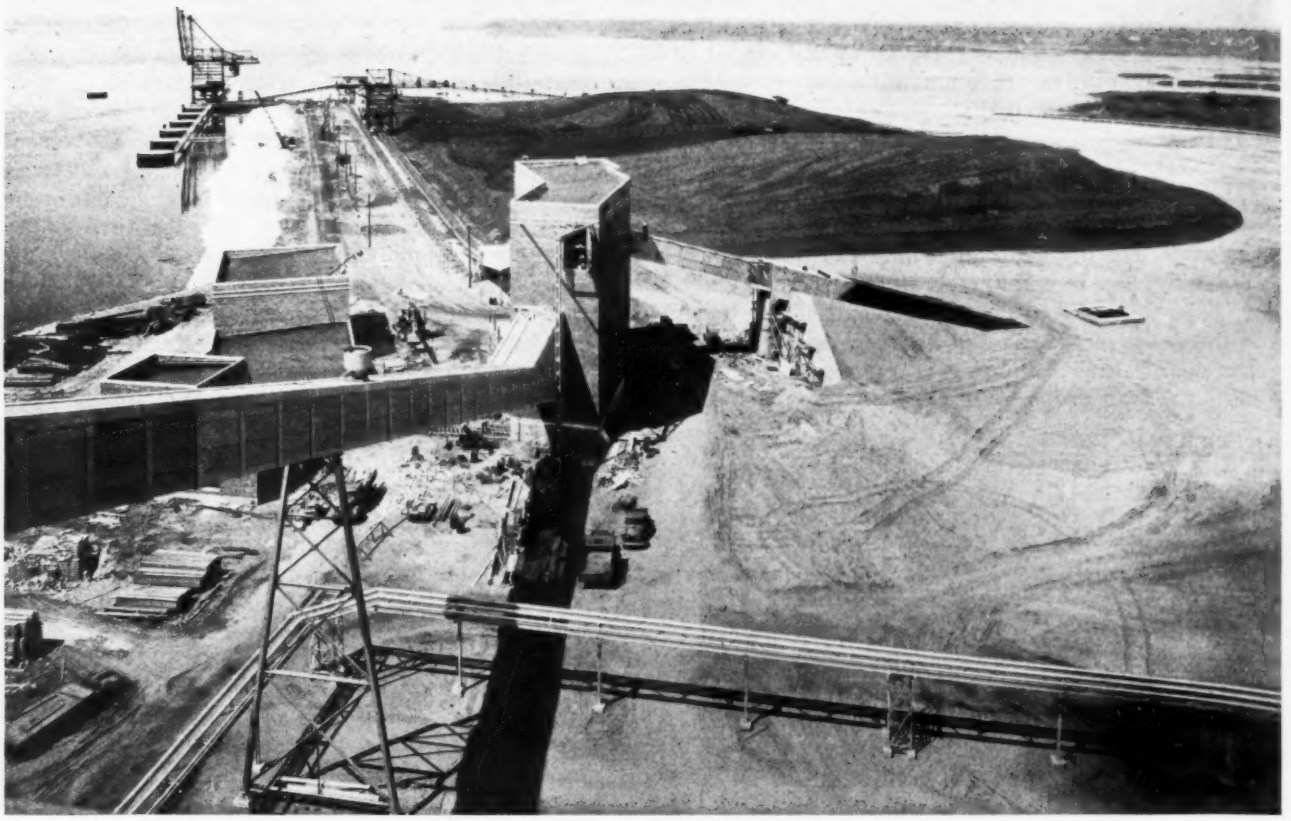


Section through boiler and turbine rooms

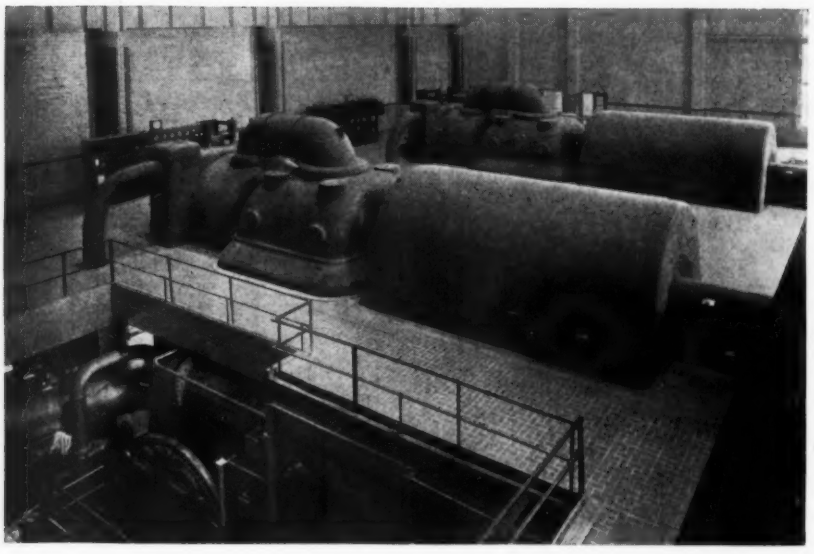
The economizer is a C-E, fin-tube type with the flue gas flowing down and counter to the direction of the feedwater. It is of the two-section type, 34 tubes wide and 18 tubes high in three units of 6 tubes each. The entire unit has a heating surface of 20,400 sq ft.

A C-E vertical counterflow plate-type air heater is employed. This is in two sections, each 30 ft high by 5 ft deep with a width of 24 ft. Spacing on the air side is $^1/_2$ in. between plates and the flue gas spaces are $^3/_4$ in. wide, each section having 370 elements. The total heating surface of the two sections is 111,000 sq ft.

Both the forced- and induced-draft fans are located on the fan floor, above the steam generators. This location makes possible a satisfactory duct and breeching arrangement and also results in a higher inlet air temperature to the forced-draft fans due to recovery of heat losses



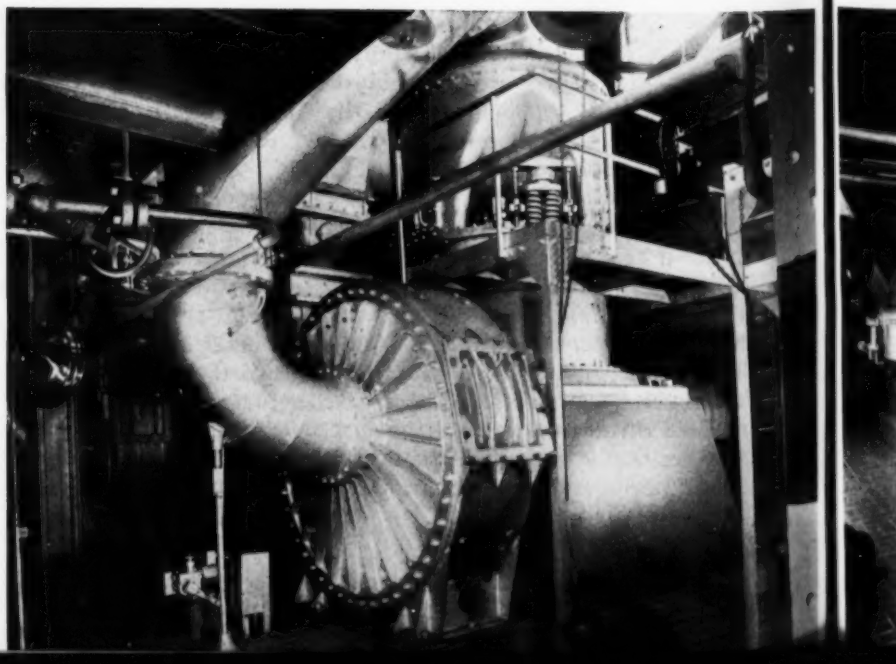
Coal-handling system



Turbine-generators Nos. 1 and 2

Views at the EC. C

Units Nos. 1 a

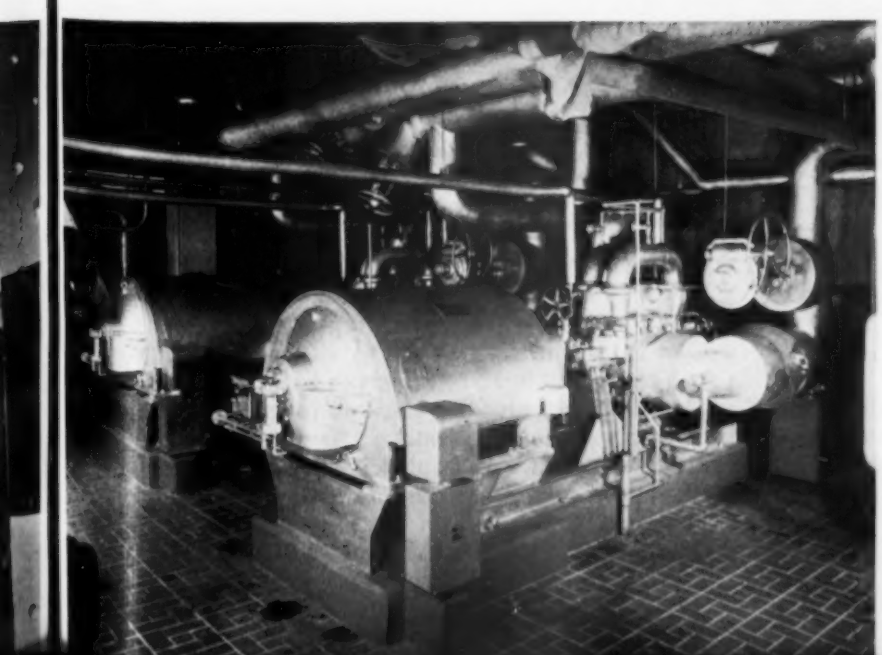


Pulverizers and exhausters
in boiler room basement

Firing aisle at operating floor

EC. Cobb Plant
Fos1 and 2

Boiler panel for steam generating unit No. 2



Boiler-feed pumps

radiated from the steam generating units at a lower elevation and also other plant heat losses. The forced-draft fan is an American Blower Type 605, Series 86, delivering 190,000 cfm of 100-F air at 12.0 in. wg. total static pressure when turning at 1140 rpm. It is driven through an American Blower hydraulic coupling by a Westinghouse, 500-hp, 2300-volt, induction motor. The induced-draft fan is an American Blower Sirocco type, handling 310,000 cfm of 330-F flue gas against a total static pressure of 13.0 in wg. when turning at 567 rpm. This fan is also driven through a hydraulic coupling.

Dust is collected by two Western Precipitation multicyclones located above the fan floor between the air heater outlet and the induced-draft fan These collectors are capable of handling a normal flue gas volume of 282,000 cfm at 315 F with a total pressure drop of 2.75 in. wg. They are guaranteed on the basis that dust in the leaving flue gas will not exceed 15 per cent of that entering the collector, providing not more than 30 per cent of the dust entering the collectors is smaller than 10 microns.

Each steam generating unit is served by its own stack, supported on the boiler room roof trusses and extending $181\frac{1}{2}$ ft above the operating floor. They are of $\frac{3}{8}$-in. plate, all-welded construction, and 12 ft in diameter with 2 in. of Gunite lining. The flue gas velocity leaving the stack is approximately 60 ft per sec at full boiler load.

The Diamond soot-blowers are of the automatic air-operated type, controlled by a program panel which is mounted on the end of each boiler panel.

The air for soot blowing is supplied by two Clark Brothers compressors delivering 750 cfm at 500 psig and driven by a 250-hp, 500-rpm, 2300-volt induction motor. This air is discharged into a high-pressure receiver tank of 200 cu ft capacity, then reduced to 300 psig and transferred to a low-pressure receiver tank of 100 cu ft capacity from which the soot blowers are supplied.

Fly-Ash Handling System

Discharge from the hoppers under the dust collectors, economizers and air heaters is connected to centrifugal hydraulic dust valves into which water enters tangentially by means of three jets, using a total of approximately 50 gpm per valve. This fly-ash laden water from the dust valves is run to a slurry tank located in the basement. From the slurry tank two 300-gpm pumps deliver the mixture of ash and water to an ash-disposal field located a short distance from the plant. The centrifugal hydraulic dust valves on the dust collectors are supplied by water previously used to cool the forced- and induced-draft fan hydraulic-coupling oil coolers, whereas those located under the economizers and air heaters are supplied by water previously used to cool the induced-draft fan bearings. Each of the water systems has a separate collector tank, ahead of the dust valves, which has an auxiliary supply from the house service system and is controlled by a float valve, for use in case the primary water supply is lost or insufficient in quantity. The slurry tank is also set up for auxiliary makeup, in like manner.

Ash-Handling System

The ash-removal system, manufactured by the Hydro-Ash Corporation and using the hydrojet type of removal, sluices the ash, by means of jets, from the boiler ash hoppers through an ash sluiceway to the ash sump. Clinker bars strain the ash and water mixture, and the clinkers over 5 in. diameter are held for hand breaking. The ash-laden water is then pumped by one of two 8-in., Nagle Brothers pumps having a capacity of 1500 gpm, through two 8-in. cast-iron ash pipes to the ash disposal field. These ash pumps cannot be started if the gland water pressure on the pumps is below that recommended by the pump manufacturer. A constant water level is maintained in the ash sump by means of a float valve supplied with water from the house service system.

Two motor-driven ash-sluice pumps supply water to an ash-sluice header. This header supplies the water used in the various nozzles in the boiler ash hopper and ash sluiceway. These pumps are of the Union Steam Pump single-stage, double-suction, horizontally split type, each with a capacity of 1200 gpm against a head of 240 ft.

House Service and Fire Protection System

The house service water system consists of a 9200-gal house service tank located on the boiler room roof and supplied by three 5-in., Union single-stage, double-suction, centrifugal pumps, each of 1200 gpm capacity against a head of 158 ft. The pump suction is obtained from the intake tunnel.

The fire-protection system consists of a high-pressure header supplied with water from either the house service pumps or the ash-sluice pumps. This header, in turn, supplies high-pressure water to the various fire cabinets throughout the plant. The fire header also supplies water to six fire hydrants in the yard, the sprinkler system in the gallery from breaker house to the power house, the reclaiming conveyor gallery sprinkler system, and fire cabinets in the breaker house. With the ash-sluice pump in operation the pressure in the fire protection header will increase, and, to protect equipment on the house service header, a check valve is installed in the interconnection between these two headers so that flow can be only from the house service header to the fire-protection header.

Water-Softening System

The water-softening system supplies treated water to the evaporators through an open heater for plant makeup. This system is a cold process lime-soda ash "Accelerator" made by Infilco, Inc., and has a capacity of 2850 gph. This softener, along with two American Marsh single-stage, 50-gpm pumps, is located in the service building, from which point the water is pumped to a 4063-gal soft-water storage tank located on the boiler room roof. The latter supplies water to the deaerating open feedwater heater for the evaporator on each unit

Coal-Handling System

The coal-handling system is of the belt-conveyor type, supplied to a large extent by the Link-Belt Company and the Industrial Brownhoist Corporation.

Coal is brought to the dock by either bulk freighters or self-unloading boats. From the bulk freighters it is unloaded by the unloading crane and carried by a feeder conveyor, at a maximum rate of 1200 tons per hour, to a transfer conveyor. Self-unloading boats discharge directly into a hopper on the side of the coal unloading

tower from which coal flows directly to the transfer conveyor.

The transfer conveyor is designed to operate at two speeds, carrying 1200 tons per hour for unloading bulk freighters and 1800 tons per hour for use with self-unloading boats. Coal from the transfer conveyor feeds onto a yard conveyor which is an open belt approximately 1230 ft long. This conveyor has three speeds, two for boat unloading and a third for use when reclaiming coal from storage. A traveling tripper in conjunction with a stacker conveyor is designed to remove coal from this belt for placing in storage. Reclaiming coal from storage is accomplished by a reclaiming crane of 600 tons per hour capacity discharging onto this belt. By varying the speeds of the feeders on the traveling tripper and reclaiming crane, coal from boats and from storage can be mixed to any desired proportions.

Coal from the yard conveyor is discharged through a chute onto a feeder in the breaker house. This chute has a removable section of back-plate which can be taken out and the feeder reversed to remove ice from the yard conveyor. A magnetic pulley is installed at the head end of this feeder for the removal of magnetic material. Coal discharged from this feeder passes directly into the breaker, or, if suitable for the pulverizers without crushing, it can be bypassed directly to the plant conveyor and conveyed over a weightometer and then to the bunkers in the plant. This conveyor has a capacity of 600 tons per hour. The plant conveyor has a traveling tripper for distributing the coal to the various bunkers.

A reclaiming hopper, feeder, and conveyor to the breaker house have been provided to reclaim coal from storage in case of failure of the reclaiming crane. Coal passing through the reclaiming hopper is discharged onto the feeder in the breaker house and can be mixed with that coming from the boat, by varying the speed of the reclaiming hopper feeder and the feeder on the traveling tripper.

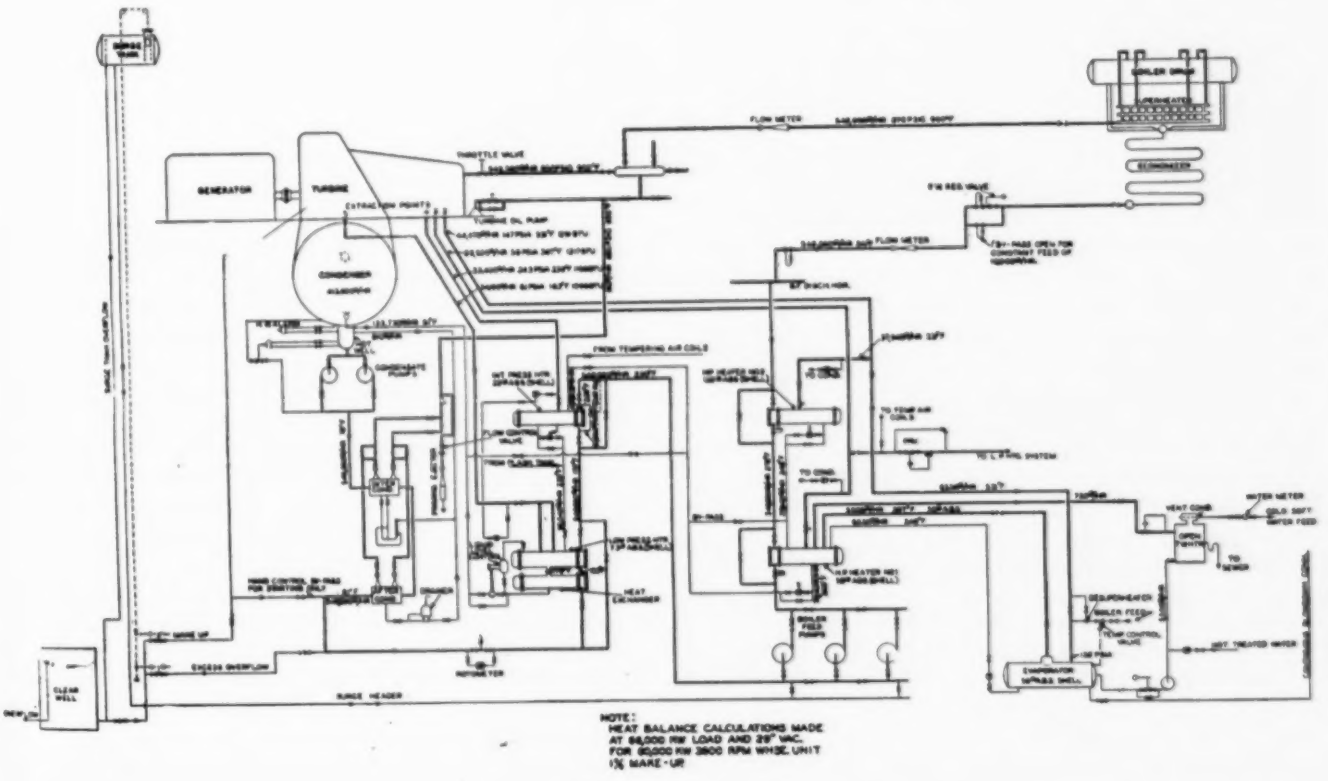
A 500,000-ton coal storage area is provided and space for additional storage, up to 360,000 tons, is available should it be required.

Bulldozers are used to pack the coal for storage together with carryalls for moving the coal over the large storage space before packing. For cleaning up bulk freighters a small bulldozer is used. An auxiliary hoist has been mounted on the bucket carriage of the boat unloading crane for getting the bulldozer in and out of the boats.

Controls and Instruments

As previously mentioned, the superheater outlet temperature is regulated by tilting of the tangential burners which is controlled from the boiler panel. In addition, two sets of dampers are provided. One set controls the gas flow to the primary superheater and the other the gas flow over the rear boiler surface. These dampers are also controlled from the boiler panel. A Leeds & Northrup Company Model R, Micromax indicating superheat temperature recorder, mounted on the boiler panel, provides the operator with the necessary information for operating these dampers.

A steam flow — air flow controller and an air flow controller are provided for regulating air for combustion. The steam flow — air flow controller balances the steam flow differential across a Bailey steam-flow nozzle in the steam header from each steam generator against the flue gas flow differential across the dust collector. This,



Heat balance diagram

in turn, regulates the induced-draft fan speed through its hydraulic coupling and the induced-draft fan damper. The air-flow controller balances the flue gas flow differential across the dust collector against the pressure of the main steam manifold, through the loading pressure from a master sender, and it also regulates the induced-draft fan speed and induced-draft fan damper to control the pressure. These two systems are designed so that either can control combustion but they are electrically interlocked to prevent parallel operation.

The feedwater regulator is a Copes two-element control type supplied by Northern Equipment Company. One element is for anticipated level changes, corresponding to steam flow, as measured by variations in pressure drop across the superheater. The other element responds to water level changes in the drum. Combined results of these two elements position the feedwater regulator valve.

Feedwater and Condensate System

The feedwater and condensate cycle employs two high-pressure closed feedwater heaters, two low-pressure closed feedwater heaters, and a drain cooler. Makeup is supplied by an evaporator, which, in turn, is supplied by an open heater. The feedwater heaters and evaporators were manufactured by Westinghouse and the open heaters by the Elliott Company. All of the closed feedwater heaters are mounted horizontally and the drain cooler is placed below the lowest pressure heater.

Steam for feedwater heating is bled from the turbine at the four extraction points selected to give the most economical regenerative cycle for full load conditions. Drains from the feedwater heaters are cascaded from heater to heater to recover the heat that is given up in flashing to lower pressures. These drains are finally collected at the drain cooler, from which they are drained into the condenser.

Condensate from the condenser hotwell is pumped through the inter- and after-condenser, the drain cooler, the low-pressure heaters, and to the suction of the boiler-feed pumps by the condensate pumps. Boiler feed-pumps then pump the water through the two high-pressure heaters to the economizers.

To take care of the varying rates of condensate flow due to changes in loads and to control the water due to evaporator operation, a high-level surge tank is connected to the boiler feed pump suction header. High water in the surge tank opens a float-controlled valve, permitting water to flow from the system through a connection between the after-condenser and the drain cooler into the condensate line. From this point the excess water flows into the clear well. Low water in the surge tank opens another valve connected to the same surge tank float, permitting the vacuum in the condenser to pull water from the clear well into the system through a perforated spray pipe, for deaeration, in the top of the condenser shell. A temperature-control valve is installed in the feedwater line by-passing the second low-pressure heater which limits the maximum temperature of the water leaving the heater to 220 F and prevents flashing in the surge tank which floats on the boiler feed pump suction header.

There are three 8-in., 6-stage, motor-driven Worthington boiler feed pumps, each with an efficiency of 77 per cent at a capacity of 1300 gpm when supplied with 220 F feedwater and operating at 3550 rpm against a total head of 2425 ft. These pumps are designed for parallel operation and each pump has sufficient capacity to supply one boiler at full load. The remaining pump is a full spare. The pumps take their suction from a common header at 220 F maximum temperature and the water is then pumped through the two high-pressure heaters to the economizers.

Makeup, calculated at one per cent of boiler feedwater flow, is supplied from the water-softening system to the open feedwater heaters from which it is pumped to the evaporators.

Circulating Water System

Condensing equipment was manufactured by Westinghouse. Each condenser is a two-pass, divided-water-box, radial-flow, deaeration type with 42,500 sq ft of surface, and $1^1/_4$-in. Muntz metal tube sheets. The condenser steam inlet connection is bolted rigidly to the turbine exhaust and spring supports are provided to limit the load placed on the turbine exhaust flange.

The air removal system consists of one two-stage, twin-element steam-jet air ejector with inter- and after-condensers operating at a reduced pressure of 400 psig, and a noncondensing single-stage priming ejector operating at reduced pressure, through a flow control valve, taking its steam from the 900-lb auxiliary steam header.

Two motor-driven circulating water pumps are provided for each unit. These are of the horizontal impeller type, each capable of pumping 27,500 gpm against a total head of 24.5 ft.

The condensate pumps supplied by Westinghouse, of which two are installed per unit, are of the horizontal three-stage type, each capable of handling 1250 gpm against a 166 ft discharge head with a 34-ft suction head. They are driven by 125-hp, 1175-rpm, 2400-volt induction motors.

One Rex, double-inlet traveling screen per unit is installed in the screen house to provide strained circulating water from Muskegon Lake. Chlorination equipment is provided in the screen house for inhibiting and preventing marine growth.

Electric Generating System

The two turbine-generators now installed are of the Westinghouse, 60,000-kw, two-cylinder, tandem-compound, double-flow, 3600-rpm, high-pressure, impulse-reaction condensing type, designed for throttle conditions of 850 psig and 900 F.

Steam to the turbine passes through the throttle and emergency stop valves then through seven admission valves into the one impulse and 34 reaction stages, of which 22 are in the high-pressure cylinder. All blades are chrome steel alloy with the last three rows of rotating blades in the low-pressure turbine shielded on the inlet edge by strips of Stellite.

Each generator is a 70,580-kva (at 0.5 lb hydrogen pressure), 85 per cent power factor, 3600-rpm, 14,400-volt, 3-phase, 60-cycle, hydrogen-cooled unit equipped with a 200-kw, 250-volt, direct-connected main exciter and a 2.5 kw, 125-volt, direct-connected pilot exciter. Both exciters are air cooled.

All auxiliaries are motor-driven. Motors of 100-hp rating and above are supplied with power from the 2300-volt bus. Those under 100 hp down to approximately

3/4 hp are supplied from the 480-volt bus. Motors of 3/4 hp or less are connected to the lighting circuits. All of this power is supplied direct from the generator leads through a Westinghouse, 6000-kva, 3-phase, 60-cycle, 14,400/2400-volt transformer, and 480-volt supply is taken off the 2400-volt bus through a 750-kva, 2400/480-volt transformer.

For starting the station, should all units stop, a tie from the transmission system through a 2500-kva, 24,000/2400-volt starting transformer has been provided.

Performance

The average performance for the first six months of operation is as follows: Net Btu per kilowatt-hour generated, 11,138; exhaust pressure, 1.03 in. Hg; station load factor, 0.727; net pound of coal per kilowatt-hour generated, 0.954; and steam per kilowatt hour generated, 8.69 lb.

General

The cost of the two-unit extension, including a coal-handling system capable of handling the ultimate plant, was approximately $139 per kw. The estimated cost of the third 60,000-kw unit is approximately $106 per kw. Based on these costs, the three-unit installation would be approximately $128 per kw.

Design and engineering for all three 60,000-kw units were carried out by The Commonwealth & Southern Corporation's General Engineering Department, Jackson, Michigan. Construction work was contracted and supervised by the Construction Department of the Consumers Power Company.

Revisions in the European Power Program

At the 1948 Midwest Power Conference, Walker L. Cisler, executive vice president of The Detroit Edison Company and consultant to the U. S. government on the power aspects of the European Recovery Program, gave a paper on "The Foreign Electric Power Situation," as it relates to the Marshall Plan. This was reported in COMBUSTION of April 1948. It explained the so-called *National* program of power expansion, calling for 21.5 million kilowatts, to be financed largely by the individual countries and the *International* program involving 2.3 million kilowatts to be financed by the United States.

There has now appeared an Interim Report by the Electricity Committee of the Organization for European Economic Cooperation. This report, which was printed abroad, contains certain downward revisions of the original estimates prepared at the Paris Conference in 1947, as necessitated by certain unanticipated postwar construction difficulties. The revised figures place the increase in power capacity possible of achievement in the four-year period (1948 through 1951) as 15 million kw. Of this, present anticipated construction under the *International* program calls for 2.8 million kilowatts at a cost of $853 million dollars.

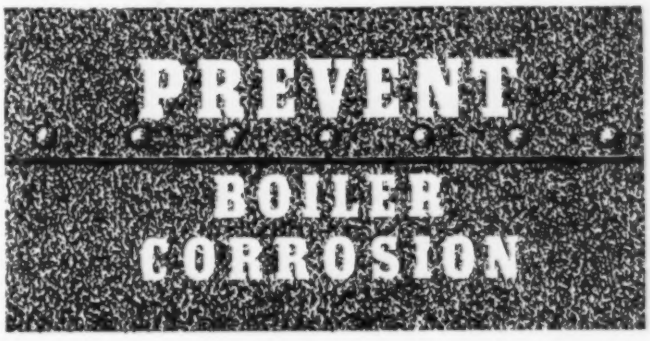
A third, or *Complimentary*, program, considered by several countries as necessary to their power development, but which will probably require special financial assistance, would add another 5 million kilowatts capacity. This would bring the total present figures for the three programs up to 22.8 million kilowatts at an expenditure equivalent to nearly 2 billion dollars. The magnitude of these requirements will be understood when it is reflected that very little capacity was added during the war years and, also, much was destroyed by military action.

A tabulation of the installed power capacities of the seventeen countries concerned gives a present figure of approximately 48 million kilowatts of which about 29 million is thermic plants (steam and internal combustion) and approximately 19 million represents hydroelectric capacity.

The United Kingdom leads in the capacity to be added through 1952 with Italy, the Bizone and France following in the order named.

Europe is said to be in a position to produce by far the larger part of the equipment required by the recovery program, but there remains a certain amount of specialized equipment that can come only from the United States. However, in view of the emergency and short time involved, it has been decided to waive standardization, especially as the equipment to be imported represents only a small part of the total investments.

The report points out that even if the most optimistic forecasts are attained there will still be a deficit in generating capacity of some 4 or 5 million kw by 1952, and that the gap can be met only by continuing the policy of restrictions in the use of electricity that is not necessary to industrial production, so that essential industries may be kept in operation to bolster the country's economic position.



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Operation and Maintenance of Steam Generating Equipment as Affected by Properties of Fuels*

A discussion of factors affecting pulverizer capacity and maintenance, and their relative importance as related to the characteristics of coals now generally available for steam generation. Also considered are the properties of coal that influence stoker operation, and the effect of impurities commonly encountered in burning fuel oil.

By ALEXANDER BOGOT

Combustion Engineering—Superheater, Inc.

IN selecting and designing present day steam-generating equipment, proper consideration must be and is given certain basic requirements. These are capacity and capacity range required, the steam temperature and control range required, the feedwater temperature, auxiliary or future fuels to be used, the primary fuel to be burned and its analysis, steam pressure and the efficiency required.

After these basic requirements are set up and agreed upon, the design factors which they govern fix the physical characteristics of the steam generator and auxiliaries comprising the unit.

When the unit goes into service, its satisfactory operation has been predicated on adherence to the above basic requirements, one of which is the type and analysis of fuel to be used. It may be said, since most of the basic requirements are fixed items of design at this point, that satisfactory operation is predicated upon the use of a fuel having a definite analysis and physical properties. Variations in the properties and analysis of the fuel "as fired," therefore affect the operation and maintenance of the unit to a greater or lesser degree depending on the extent and nature of the variation.

Of the three major fuels used in utility practice, coal varies considerably, while natural gas will vary the least, with fuel oil in not quite as enviable a position as natural gas.

The properties of coal, as regards its use in steam generating practice, may be listed as follows: heating value expressed in Btu per lb, either on an as-received, as-fired or dry basis; volatile matter; fixed carbon; ash content; ash-fusion temperature; moisture content; sulfur content; grindability; sizing; iron oxide content of the ash; and burning characteristics of the fuel; i.e., whether it be caking or free burning. The last three properties, although having some effect on the operation of pulverized-fuel-fired equipment, are especially important in stoker-fired units. It is not uncommon, particularly in the Southeast, to have a yearly summary of coals used in a given plant read as follows: heating value range from 11,000 to 13,000 Btu per lb; volatile matter 21.0 to 35.0 per cent; sulfur 0.7 to 4.0 per cent; ash 6 to 20 per cent; moisture 5 to 15 per cent; grindability 40 to 90 Hardgrove; ash fusion temperature 2300 to 2800 F; and sizing from run of mine to $^1/_8$ in. × 0.

The properties of fuel oil as concerns utility practice may be listed as heating value, flash point, sulfur content, ash content and viscosity.

Those of natural gas are its heating value and chemical composition. These are dependent upon the locality where the gas is produced and, since the supply to a given plant usually comes from a given locality, the heating value and chemical composition are normally quite consistent.

Pulverized Coal

The almost complete mechanization of large-scale mining and the need for retention of fines as a salable product in order to operate economically, plus the increasingly greater quantities of strip-mined coal being made available, have been responsible for a consistent rise in ash content of coals obtainable for steam generation. Gradual degradation of coals and the increased prices for fuels of the same quality have also been factors in the downward trend in grindability of coals available for a given plant.

Pulverizing capacity is installed on the basis of coal grindability, moisture content, heating value and fineness of product required.

Grindability is not an inherent property of coal, such as moisture and ash, but is merely a means of indicating the relative ease with which coals can be pulverized when tested in a particular type of apparatus. The Hardgrove method which utilizes a miniature of a commercial type of pulverizer is the most commonly used and simplest form of grindability determination. A soft eastern bituminous coal was selected as an arbitrary standard and given a grindability index factor of 100. Pulverizer

* Prepared for presentation before the Southeastern Electric Exchange at Roanoke, Va., Sept. 20, 1949.

capacity though not directly proportional to grindability is considerably affected by it.

In many plants pulverizers were installed on the basis of operating with coals having a grindability index of 60 to 70 Hardgrove and full steam generator capacity requiring 75 to 85 per cent of total pulverizer capacity. This same equipment is today being supplied with coals having a grindability index of 45 to 50 Hardgrove, which decreases pulverizer capacity in the ranges noted approximately 15 to 25 per cent, thus completely eliminating the excess capacity originally available. Ability to maintain constant steam pressure to the turbine throttle is reduced, and the proper operation of the combustion control system is considerably impaired. Where effect of wear, depending on design, reduces capacity, it has been found necessary to replace the elements more frequently.

Grindability vs Wear

Although maintenance on pulverizing equipment is frequently referred to in conjunction with grindability, it is incorrect to assume that grindability determines wear. Wear is a function of both the hardness and abrasiveness of the material being ground, whereas the grindability index merely indicates the relative ease with which the coals are broken down to a definite sizing. Generally speaking, a coal of 100 grindability will not produce the same amount of wear as will a coal having a 50 grindability. There will be practically none of the harder fractions in the 100 grindability coal which require retention in the pulverizing system for regrinding until the fineness is up to requirements. These harder fractions must make more passes through the grinding chamber.

An excellent example of the fallaciousness of wear being a function of grindability would be a comparison of Alabama coals such as are burned at the Alabama Power Co.'s plant at Gorgas, and Illinois coals as burned at the Commonwealth Edison Co.'s plants in Chicago. Both are approximately 55 grindability; but at Gorgas, on pulverizers of comparable size to those at Chicago, the wearing elements give a service hour and tonnage life over 300 per cent greater than do those pulverizing the Illinois coals. This is in large part due to the fact that Gorgas uses washed coals. In reducing the total ash in the fuel, most of the really abrasive materials such as slate, trap rock and pyrites have been removed.

Moisture content of the raw fuel as delivered to the pulverizer also affects the capacity, depending on the quantity and temperature of heated air available for drying the coal. This drying is necessary to facilitate grinding and to insure good ignition at the burner. The quantity of moisture left in the fuel when it enters the furnace, and therefore the amount of pulverizer drying required, depends on the kind of coal being ground. With eastern coals of relatively dense structure it is necessary to dry down to 1.0 or 2.0 per cent moisture With midwestern coals drying need be carried down to only 4.0 or 6.0 per cent and with lignites only 17 to 28 per cent is necessary. Texas lignites have been fired satisfactorily when dried to the latter figure. Fortunately, the amount of the more readily removable surface moisture decreases as the density of the coal increases; and it is this surface moisture which has the greatest effect on pulverization. Thus, a lignite containing a total moisture of 35 per cent might require only 10 to 12 per cent moisture removal. This would correspond to the same amount of drying as with midwestern coals at 16 to 18 per cent and eastern coals at 12 to 14 per cent moisture.

If the moisture content of the raw fuel is in excess of that for which the equipment was designed and sufficient air temperature for drying is not available, the pulverizer output will be limited to its drying and not its grinding capacity.

Also, the capacity of a pulverizer is based on the weight of coal fed to it. There are more Btu available per pound of 4 per cent moisture fuel than if the moisture were increased to 10 per cent. Thus, for the same boiler output the amount of fuel fired will have to be increased accordingly. If pulverizers have been selected on the basis of low moisture fuels they will be too small with high moisture fuels.

This would lead one to believe that grinding equipment should be installed on the basis of the highest possible moisture fuel obtainable and, by the same token, on as low a grindability and Btu coal as is economically possible to obtain at a given plant. However, certain other factors in the operation of a plant do not permit this. The air heater design is predicated, in part, on the moisture content of the fuel and the amount of drying required in the mill system. If high-moisture fuels require 650 F air and normal coals run considerably lower in moisture, large quantities of tempering air will have to be used at the pulverizer to keep the air-coal mixture temperature down to 175–185 F. This air does not pass through the air heater and results in a drop in air heater and overall efficiency. Also, a lesser quantity of coal will be required. This would also be true if the equipment is designed for a low Btu value coal and fuel of a higher Btu value is used.

The pulverizer, if selected large enough to allow for the simultaneous occurrence of the foregoing conditions, would be considerably oversized; and where this has been done it has imposed an additional operating problem for minimum loads by raising the minimum load safely obtainable on normal fuels. Power requirements with a given capacity pulverizer increase on a per-ton basis as rating is reduced so that a pulverizer at 50 per cent load would take approximately 20 per cent more kilowatt-hours per ton of coal ground than it would at full load. Maintenance costs would also tend to increase since the wear on the major parts of a pulverizing system is more a function of service hours than of tonnage. This is true because a considerable amount of grinding is accomplished by attrition between coal particles themselves as well as between coal particles and grinding elements.

Volatile Determines Fineness

The fineness to which coal is ground is largely determined by the volatile matter. Since high-volatile coals ignite more readily than do those with a low volatile content, it is not necessary to pulverize them to the same degree of fineness. With the exception of anthracite which has both a low grindability and a very low volatile content, low-volatile fuels have higher grindabilities than the high-volatile fuels. Where a change has been made from low- to high-volatile fuel, the reduction in pulverizer capacity due to grindability change can be partly offset by reducing the fineness of grind.

For a given plant with a definite fuel there is an optimum fineness of grind. This will depend in part upon the type of grinding equipment, the grindability of the coal, its volatile content and the burner and furnace design. A given size and type of pulverizing equipment will, with a given grindability fuel, produce an end product having a definite relationship between the plus 50- and minus 200-mesh materials. The quantity remaining on the 50-mesh screen will affect the carbon loss and slagging conditions in a unit, the extent depending on the type of furnace, (whether dry or wet bottom) the type of firing and the excess air in the furnace. Generally, the on 50-mesh is specified as not more than 1 to 2 per cent.

Fineness Measured by 200 Mesh

The quantity that will pass through 200 mesh is specified as from 65 to 85 per cent. If a given fuel requires 75 per cent through 200 mesh for good ignition and the pulverizer produces less than 1 per cent on a 50-mesh screen when grinding at this fineness, any increase in the percentage through 200 mesh to effect a reduction in the plus 50 mesh percentage merely increases the power requirements and reduces capacity without materially affecting furnace conditions. Grinding finer than necessary, in addition to increasing power requirements, also increases grinding element wear and maintenance costs. This is because it is the harder fractions in the coal that make up the coarse particles remaining in the system for further regrinding.

With tangentially fired slagging-bottom furnaces using free-burning high-volatile coals, the plus 50 mesh can run as high as 2.5 per cent with 65 per cent through the 200-mesh screen without increasing carbon loss or getting into slagging difficulties.

The caking or agglomerating coals from the eastern fields when burned in tangentially fired or turbulent furnaces of sufficient volume, need not be ground finer than 75 per cent through 200 mesh with less than 1 per cent on a 50-mesh screen. In smaller furnaces with horizontal turbulent burners it may be desirable to use a fineness of 80 per cent through 200 mesh with the medium volatile fuels, and 85 per cent through 200 mesh with the lower volatile fuels. These same furnaces on midwestern coals will require only 75 to 80 per cent through the 200-mesh screen.

Raw Coal Sizing

Raw coal sizing must be kept within reasonable limits. It is customary to specify $^3/_4$ in. $\times$ 0 for the small and $1^1/_4$ in. to $1^1/_2$ in. $\times$ 0 for the large pulverizers. Many plants are grinding fuel sizes much smaller than these but the handling of wet fine coals from the storage pile to the grinding equipment has introduced operating problems with which most operators are familiar. Stopped-up bunker outlets, plugged downspouts and feeders and "archovers" and "ratholing" in hoppers are not at all conducive to the high availability required of present-day steam generating units. With these units it is essential that a steady and uninterrupted flow of raw fuel be maintained.

With fine dry coal the operating problem becomes one of maintaining a uniform feed; i.e., eliminating the possibility of flooding the feeders. With a very coarse coal the possibilities of jamming feeders arise and the automatic control system, because of unevenness of coal supply, will have a more difficult task in maintaining steady steam characteristics. If coal sizing is used as previously mentioned, coal feed to the mills will be both gradual and uniform.

Effects of Increased Ash Content

In many stations, equipment that was designed for use with coals having a six per cent ash content is now being supplied with coals having a range in ash content of 15 to 20 per cent. This increase invariably is followed by an increase in unburned carbon loss and its accompanying reduction in operating efficiency.

The reduction of heating value per pound of fuel as fired increases the total fuel requirements and this factor in itself has made some existing pulverizer capacity inadequate to carry plant peak loads.

In steam generating units having gas pass velocities of 120 to 140 ft per second, the increase in fly ash being carried by the gas stream has caused innumerable outages for replacement of tubes which have been eroded to the point where their loss was an all too common occurrence. This has been a factor influencing the latest design of units having no baffles and wider spacing of tubes with low gas-pass velocities ranging from 30 to 50 ft per second.

Dust collecting and ash removal systems are designed for certain gas flows and ash quantities. In some cases overloading of dust collectors due to increased ash content of the fuel has increased the stack discharge to a point where it has been necessary to install secondary collection equipment to mitigate the atmospheric dust nuisance. More frequent removal of ash from hoppers is necessary and increased wear and maintenance of the ash-handling equipment result.

Maintenance of induced-draft fans is directly affected by high ash content, particularly where they are not preceded by dust-collecting equipment. The extent of this wear can be such that outages for repair of fans considerably reduce unit availability.

The design of furnaces and superheaters is in part predicated on a furnace exit gas temperature which is limited by the initial deformation temperature of the ash in the coal. A change in the coal being used or the use of a mixture of the fuels which will produce a reduction in this initial deformation temperature of the ash, can cause slagging conditions in the furnace and on boiler screen and superheater elements with attendant difficulties in maintaining rating and possible loss of superheater elements.

A combination of high gas velocities and high furnace exit gas temperature may require the use of premium high-ash-fusion-temperature fuels.

Stoker Firing

Where stoker firing is employed, there are, besides the properties of coal already discussed and with the exception of grindability, certain other important properties which affect operation and maintenance of equipment. These are, chemical analysis of the ash, particularly in respect to the iron oxide content, and the caking or free burning properties of the coal.

Generally speaking, prior to the advent of the spreader stoker and the use of the Coxe traveling grate stoker on non-caking bituminous and lower rank coals, stoker types

were selected on the basis of the fuels available in the locality in which the installation was to be made. That is, the traveling grate stoker was used for anthracite and the grates were designed for definite fuel sizings: the single-retort and multiple-retort stokers were used for caking coals and the chain grate type for non-caking or free-burning bituminous and lower rank fuels. Best results in respect to operation and maintenance in each case required that fuel sizing and other characteristics be maintained within the range for which the unit was designed, since the stoker, furnace design and volume would not allow for much variation in these characteristics. High unburned carbon losses, clinker formation, low operating efficiencies, excessive slagging and high maintenance costs were the penalties.

Although the spreader stoker will satisfactorily burn a wide range of fuels and is very adaptable to variations in fuel quality, fuel sizing, because of its effect on coal distribution over the grate area, quantity of carryover, carbon losses and clinkering tendencies, is of considerable importance. The grate area is, as in other types of stokers, dependent on the quantity of ash in the coal.

High-moisture fuels, besides affecting stoker performance and pulverizer capacity, will, because of the increased percentage of water vapor in the flue gas, reduce the unit efficiency. This increased amount of water vapor, particularly when accompanied by increased quantities of sulfur trioxide resulting from high sulfur in the fuel, raises the dew point of the flue gas to a point where corrosion and fouling of the air heater may become a problem, which is an operating and maintenance difficulty common to both coal and oil.

Natural Gas and Fuel Oil

With both natural gas and fuel oil, the formation of water vapor in the flue gas results primarily from the combustion of hydrogen. In some areas, hydrogen sulfide or organic sulfur vapors are present in natural gas and here the formation of SO_3 further aggravates the problem of air-heater corrosion. Fuel oils contain sulfur in varying quantities, depending on their source and whether they be crudes, straight run or cracked residuals. Very little, if any, crude is now being used as heavy fuel oil and the advent of the cracking processes to produce higher yields of the lighter ends has produced a higher ash and higher sulfur content residual. For equal percentages of sulfur in fuel oil and coal, more cold-end heating surface damage can be expected with the former because of its high hydrogen content and resulting high water vapor content in the flue gas.

In order to prevent the fouling of air heater surface, exit gas temperatures must be maintained sufficiently high to prevent condensation. Unit efficiency therefore suffers. Inlet air temperatures to air heaters are sometimes raised by auxiliary heating or by recirculating heated air. In some cases exit gas temperatures are increased through by-passing air around the air heater. Fouling of air heaters has, on numerous occasions, been a limiting factor in maintaining continuity of service. Because of the repeated outages and maintenance, manufacturers are redesigning heaters of both the regenerative and recuperative types to minimize the corrosion and fouling rate, as well as the time necessary to make repairs and clean the surfaces.

Difficulties Caused by Impurities in Fuel Oil

Where fuel oil is used as a major fuel, its ash content can cause as much difficulty as the sulfur and the moisture produced from the burning of hydrogen.

Depending upon the fields from which the crude is obtained, the incombustible impurities in the oil, except for the water, made up as they are of natural salts plus chemicals from refining operations, may vary considerably and include a large portion of natural elements.

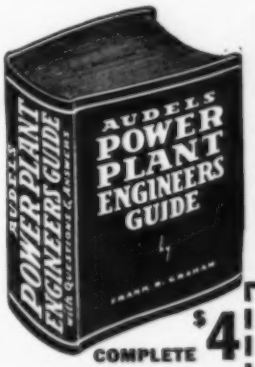
Certain salts employed in the refining process remain in the residual product and result in two different types of ash: (1) a low-fusion water-soluble ash that deposits on superheater surface and (2) a high-fusion ash. Where these are combined the product is not water soluble and is difficult to remove.

In some case the impurities cause rapid wear of pumps, valves and burner parts. Some impurities form ash in the furnace which causes rapid wear on exposed refractory. Others form slag coatings which are exceedingly difficult to remove except by manual means with the unit out of service. Still others, such as vanadium, attack nickel in high temperature alloy castings.

Variations in viscosity of the fuel can readily be handled in the heating of the oil and, since fuel oil must be heated to reduce its viscosity for proper atomization, this does not usually pose much of a problem.

Modern large steam generating units for utility service are designed to give high efficiencies over long continuous periods of operation and have sufficient leeway in their design so that a considerable variation in fuel characteristics will in no way impair continuity of service. It should be remembered, however, that to do this, compromises in selection of equipment may be necessary. Therefore, during the time that extreme variations in fuel characteristics exist, some phase of the unit's operation may not be at its best.

The economics of coal production and utilization is pointing toward lower ash and lower moisture fuels through employment of coal cleaning and washing facilities and, where necessary, flash-drying equipment to reduce the moisture content of washed fines by as much as 10 per cent before mixing with the screened sizes. It is to be hoped that this trend will continue.



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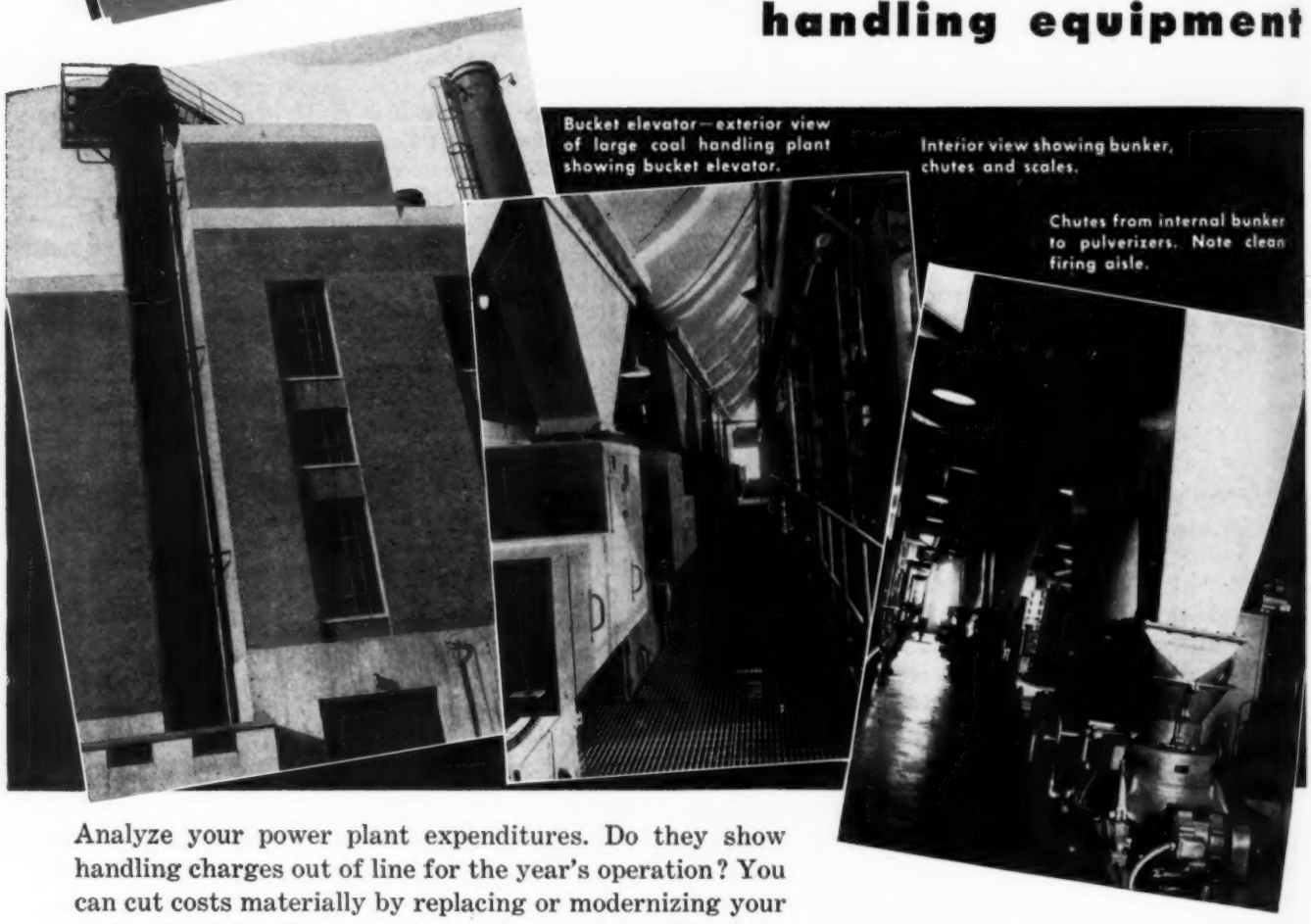

Bucket elevator—exterior view of large coal handling plant showing bucket elevator.

Interior view showing bunker, chutes and scales.

Chutes from internal bunker to pulverizers. Note clean firing aisle.

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Flue Gas Temperature Measurement at Low Velocities

By R. B. BAREFOOT
and A. H. ZERBAN

State College, Pa.

Results of an investigation made to ascertain the influence of various factors on errors in temperature measurements of low-velocity gas flow by means of thermocouples. The temperature range was from 280 to 750 F and results with bare and multishielded thermocouples are compared

FLUE gas temperatures are of such paramount importance in combustion work that their determination merits consideration. A satisfactory measurement of temperature of a hot gas moving at low velocities is not easy to achieve. For instance, Rohsenow and Hunsaker[1] have presented a method of determining a thermal correction for a single shielded thermocouple placed in a hot gas stream, and Emmons[2] has worked with a multi-

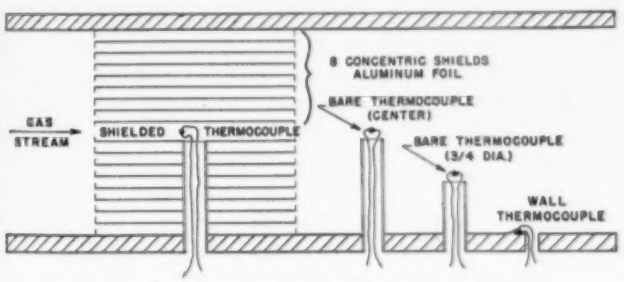

Fig. 1—Arrangement of therocouples

shielded thermocouple placed in a gas stream where he found that a thermocouple surrounded by eight concentric shields resulted in virtually a true gas temperature for moderate temperature elevations. These authors indicate that a simple thermocouple installation is inadequate for the determination of true gas temperatures.

It is often desired to measure gas temperature where the gas is flowing slowly (below 50 ft per sec) in a duct system, the duct walls having a lower temperature than that of the gas. This results in a radiant exchange of energy between the thermocouple placed in the gas stream and the duct walls which the thermocouple can see. The thermocouple will receive heat from the gas and will reach an equilibrium state when the energy received from the gas, mainly by convection, equals the radiant energy exchange between the thermocouple and the duct wall. This results in a temperature reading lower than the true gas temperature but somewhat above the duct wall temperature, the amount of divergence depending upon the rate of convection heat transfer compared with the rate of radiant energy transfer.

In an attempt to define the various factors influencing the degree of error encountered in gas temperature measurement the system shown schematically in Fig. 1 was used. This system was placed in the duct carrying flue

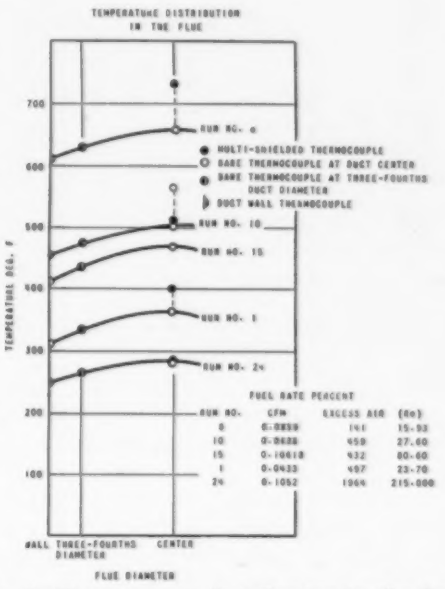

Fig. 2—Temperature distribution in the flue

gases from an experimental gas burner operated under controlled conditions. Measurements of hourly fuel consumption and of air-fuel ratio were made as well as temperature measurements. The results of more than 30 test runs are presented here. The range of temperatures encountered in the experimental work was from 280 to 750 F, determined by the multi-shielded thermocouple.

Results

In order to show the effects of duct characteristics, mass flow and temperature elevation, Fig. 2 is presented with temperature and duct diameter as coordinates. In

[1] W. H. Rohsenow and J. P. Hunsaker, "Determination of the Thermal Correction for a Single-Shielded Thermocouple," ASME *Trans.*, Vol. 69, Aug. 1947.
[2] H. W. Emmons, "Development of Temperature Probe—Multi-Shielded Type," 1944 Report to the Elliott Co., Jeannette, Pa.

this chart a typical cross-section of test results is indicated illustrating several known facts: (1) the loss due to radiant energy exchange, being proportional to the temperature to the fourth power, will increase markedly with increase in temperature elevation; and (2) the heat transferred by convection will increase with increased mass flow and the bare thermocouple will give readings indicative of the true gas temperature.

For purposes of illustrating the effect of mass flow on error encountered in gas temperature measurement, Fig. 3 is shown. Here T_s is the gas temperature indicated by the multi-shielded thermocouple, T_b is the temperature of the bare thermocouple and (Re) is the gas Reynolds Number based on thermocouple diameter. This curve indicates that for low Reynolds Numbers the error introduced when using a bare thermocouple to read gas temperature is very large and the curve will approach zero Reynolds Number asymptotically. This indicates that for low mass flows the radiant energy loss by the bare thermocouple is excessive and some other means must be used for measuring the true gas temperature. If a large mass flow exists, it is seen that the encountered error is small and as the mass flow becomes infinitely large, the

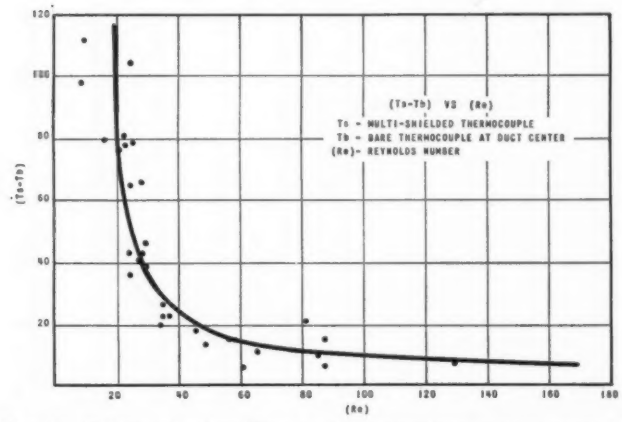

Fig. 3—Effect of mass flow on temperature measurements

radiant energy exchange will be negligible and a bare thermocouple immersed in the gas stream will give satisfactory results.

A form of Nusselts Number (h/k) (leaving out diameter) was used as the abscissa in Fig. 4. The convection coefficient of heat transfer was determined from test results by equating radiant heat transfer from the bare thermocouple with convection heat transfer to it. Hence,

$$h_c(T_s - T_b) = Ce\left[\left(\frac{T_b}{100}\right)^4 - \left(\frac{T_w}{100}\right)^4\right]$$

where

h_c is convection coefficient of heat transfer
C is Stefan-Boltzmann constant (0.1723)
e is emissivity of bare thermocouple surface (assumed 0.8)
T_s is multi-shielded thermocouple reading
T_b is bare thermocouple reading
T_w dis uct wall temperature

This figure, when compared with Fig. 3 indicates that the convection coefficient of heat transfer is proportional to Reynolds Number (Re) and a mathematical comparison would show:

$$\text{Nusselts Number } (Nu) = \text{constant } (Re)^m = \text{constant}\left(\frac{\text{diameter} \times \text{mass flow}}{\text{dynamic viscosity}}\right)^m$$

In order to verify the validity of the test results, Fig. 5 is presented. The ordinate in this figure is indicative of the heat transferred by convection to the bare couple and the abscissa is indicative of the heat transferred by radiation from this thermocouple. The mass flow (C) is proportional to the convection coefficient of heat transfer raised to some power (m). Analysis of this figure indicates that the temperature reading given by the

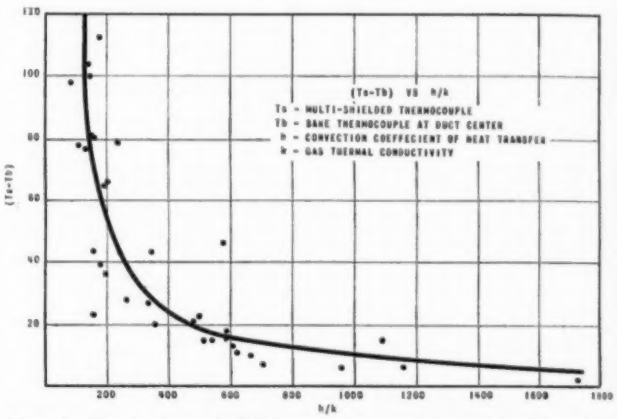
(Ts-Tb) VS h/k
Ts - MULTI-SHIELDED THERMOCOUPLE
Tb - BARE THERMOCOUPLE AT DUCT CENTER
h - CONVECTION COEFFECIENT OF HEAT TRANSFER
k - GAS THERMAL CONDUCTIVITY
(Ts-Tb)
h/k

Fig. 4—Variation of difference in reading with Nusselts Number

multi-shielded thermocouple, T_s, is for all practical purposes the true gas temperature, since the convection and radiation energies balance.

By contrast with the results obtained with products of combustion, saturated steam was next used as the flowing gas medium. In the case of saturated steam, the convection coefficient of heat transfer would be large, approximately 2000, and radiation losses would be small due to the tendency of the steam to heat the duct wall to

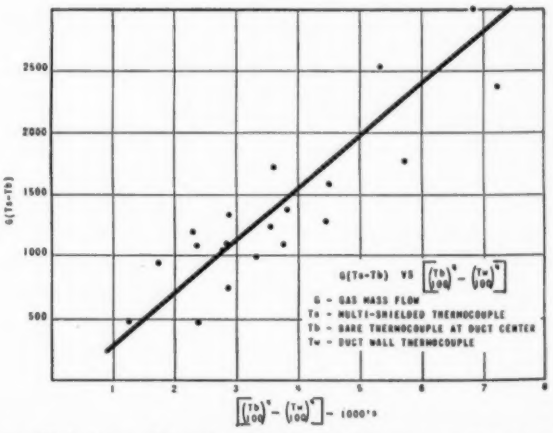

Fig. 5—Relation of heat transferred by convection to that transferred by radiation

almost the steam temperature and therefore it may be expected that the error encountered in its temperature measurement would be small. The results obtained from the test set-up substantiated the above discussion with all thermocouples reading virtually the same temperature.

A.S.M.E. Fall Meeting at Erie

KEYNOTE of the Fall Meeting of the A.S.M.E., held in Erie, Pa., September 27–30, was the urgent need for active participation by engineers in public affairs. Decrying the complacency of an American citizenry who allow government to expand without realizing the cost of bureaucracy, several speakers emphasized the necessity of selling the American people on the economic facts of the free enterprise system as the bulwark of democratic freedom. There were 21 technical sessions and nearly 50 papers covering a wide variety of mechanical engineering topics, including many of interest in the steam power field.

The welcoming luncheon featured greetings from Joseph C. Martin, mayor of Erie, and G. R. Fryling, president of the Erie Manufacturers Association, and an address outlining the engineering history of Erie by M. E. Graham, secretary of the Hammermill Paper Company.

At the second luncheon session K. B. McEachron, Jr., of the General Electric Company, spoke on the topic, "Civic Responsibility Is Everybody's Business Now." Failure to take an active part in civic affairs may lead to loss of freedom, and engineers who are bound to the realism of facts and figures should apply that same practical thinking to economic and government affairs. Mr. McEachron decried the tendency to place dependence upon the government and to replace initiative by self-subservience. Gradual changes in government may eventually lead to collectivism unless there exists a greater awareness of the path now being followed.

The banquet meeting featured an unusual acceptance message by A.S.M.E. President-elect James Cunningham, who spoke from White Sulphur Springs, W. Va., by means of a special telephone connection. President James Todd then told the assemblage that the entire economic picture is a challenge to the engineering profession, and he paid tribute to Herbert Hoover and the work of his committee on the reorganization of the executive branch of the federal government. Mr. Todd also reiterated the importance of engineers participating in civic affairs and the need to oppose the welfare state. These thoughts were further amplified by Senator Edward Martin of Pennsylvania, who warned that the trend toward centralization in government perils freedom. This is true whether the government authority is called socialism, fascism, communism or statism.

Fly-Ash Erosion in Boilers

Of special interest to boiler designers and operators was the first Power and Fuels Session which was devoted to fly-ash erosion. Four papers were presented, namely: "Fly Ash from Stokers," by **E. M. Powell** of Combustion Engineering-Superheater, Inc.; "Fly Ash Erosion in Boilers," by **L. V. Andrews** and **C. F. Hawley** of Riley Stoker Corp.; "Fly Ash Erosion of Boiler Surface," by **W. D. Stevens** of Babcock & Wilcox Co.; and "Fly Ash Erosion in Boilers," by **A. R. Weismantle** and **N. C. Artasy** of Foster-Wheeler Corp. All authors were in general agreement as to the causes.

Listing the three primary factors contributing to the rate of fly ash erosion as the quantity of dust, its nature (abrasiveness) and its velocity, **Mr. Powell** concentrated his attention on the first of these with particular reference to stoker firing. With this type of firing the most important items contributing to cinder carryover are sizing and ash content of the coal, the firing rate, and the quantity of cinders collected in hoppers and returned to the furnace for recovery of unburned carbon. To illustrate, he cited the results of recent tests on two units fired with continuous-discharge spreader stokers; one arranged to reinject the cinders from hoppers under the boiler passes, economizer and dust collector; the other to reinject those from the boiler hopper only.

The results were cited to point out the factors that must be balanced against the gain through complete reinjection. These include increased maintenance, brought about by higher dust loading, and increased dust discharge from the stack unless the rate of firing be limited.[1]

Messrs. Andrews and **Hawley** attributed erosion of boiler tubes by fly ash principally to a tendency to burn more coal per foot of boiler width. Usually one or more of the following conditions exist:

1. Separation and concentration of abrasive material on baffles in such manner that particles impinge on tubes as they stream off the baffle.
2. Concentration of abrasive particles by centrifugal action when dust-laden gases are forced to turn in restricted passages before passing over subsequent heating surface.
3. Localized areas where gas velocities are greatly increased by restricted gas passages.

The authors illustrated these points by citing several case histories.

The first was a traveling grate installation burning No. 4 buckwheat of 12 to 16 per cent ash and sized to pass through a $^3/_{32}$-in. round-mesh screen. Fly ash caused erosion on the rear row of the front bank of boiler tubes where the gases turned abruptly and there was a separation of the coarse particles by centrifugal force. To remedy this situation semi-circular liner pieces were tack-welded to the boiler tubes at this spot. There was also some polishing action of the tubes at the bottom of the last pass and some at the entrance to the economizer; but neither of these caused tube failures.

The second case was an installation burning blast-furnace gas and pulverized coal where abrasive dust separated out of the gas stream in the 180-deg turn ahead of the economizer. Here the concentrated dust impinged on the rear rows of economizer tubes with sufficient force to cause abrasion, requiring renewal after five years' service. However, there was no erosion of the boiler tubes, despite the high flow rates employed with a combination of blast-furnace gas and pulverized coal.

[1] Mr. Powell's paper will appear in the November issue of COMBUSTION.

In another installation, where there was concentration of fly ash particles on the shelf baffles, the refractory seal at the junction between the shelf baffles and the vertical baffles had been overlooked during erection. This permitted dust particles to pass through the opening at high velocity and cause tube failure after about five years of operation.

While the authors had not found such erosion to present a serious maintenance problem they offered the following recommendations:

1. Maintenance of low gas velocities in the upper furnace, particularly where the gas enters the boiler tubes.
2. Low gas velocity where turns are made.
3. Use of overfire air to reduce carryover, particularly with stoker firing.
4. Competent field reports.

Mr. Stevens attributed tube erosion to one or more of the following observed conditions:

1. Streams of ash which have concentrated on baffles due to centrifugal force caused by turning the gas stream.
2. Ash particles well distributed in a high velocity gas stream. This may erode the entire tube bank.
3. Particles leaking at high velocity through baffles.
4. Ash carried by high velocity gas flowing in wide lanes between the heating surface and the walls. This type of corrosion has occurred mostly in continuous-tube economizers.
5. Ash caught in eddy currents around U-bolts or other projections which erodes the surface close to the projection.
6. Extremely turbulent conditions at the entrance to the tubes of a fire-tube boiler before the gas straightens out for long flow through the tubes.

Various examples were illustrated by slides, but of these the most frequent was shown to be erosion by streams of ash which have been concentrated on baffles.

"Erosion," said Mr. Stevens, "is undoubtedly a function of the weight and velocity of individual ash particles, the quantity of ash that hits a particular spot, the abrasive qualities of the ash, and the angle at which the particles strike the surface. Experience indicates that for any combination of ash, type and concentration, there is some critical velocity below which no trouble from erosion can be expected and above which serious erosion will occur. This velocity is not an exact value because there is an in-between zone where polishing of the surface will occur without serious erosion."

A number of steps can be taken toward avoiding such erosion. These include single-pass design; the cyclone furnace; employment of a cinder-catcher baffle, or slot, which allows the concentrated ash to discharge into a relatively dead area; replacement of U-bolts holding baffles by field-welded studs; tight baffles; elimination of lanes or open spaces along the walls at the outside of a tube bank; control over quantity and abrasiveness of ash carryover through sizing; cleanliness of coal; use of overfire air and location of cinder returns; and, finally, maintaining gas velocities below certain values based on statistical studies. These values for various fuels and types of firing, referred to 100 ft per sec which can be tolerated with pulverized coal in boilers having baffles that do not concentrate the fly ash, are as follows:

	Allowable Velocity Ratio (1)	(2)
Pulverized coal Underfeed stoker Blast-furnace gas	0.75	1.00
Spreader stoker Anthracite or coke breeze on chain grate	0.60	0.75
Bituminous coal on chain grade	1.00	1.20
Wood or waste fuels containing sand	0.50	0.60
Cyclone furnace	No apparent erosion	

(1) Applies to the limit at, or anywhere downstream of a baffle, which tends to concentrate ash and then permits the concentrated steam of ash to impinge on the boiler tubes.
(2) Applies to single-pass boilers or those with baffle arrangements which do not concentrate the fly ash.

The paper by **Messrs. Weismantle** and **Artsay** commented on the complexity of the problem, inasmuch as fly ash erosion is seldom common to all boilers in the same plant, to all boilers of the same design, or to boilers fired by the same fuel and the same method of firing.

Five cases encountered by the authors' company were described. These included two central station units burning pulverized bituminous coal and three medium-size units burning pulverized anthracite. Erosion occurred in various locations, including tubes, kicker baffles and economizers; but in each case operation was being carried on with a higher ash fuel than contemplated in the original design. The principal remedy was lowered velocity of the gases and in some cases protection of the tubes by steel pads.

From these experiences some of the more serious factors in fly ash erosion in boilers were listed as excessive ash in the fuel, abrasiveness of ash (increased by unburned carbon or coke), particle size, high velocity of gas with deflection of particles by baffles, or high velocity through leaks in baffles, and settling out of dust in baffles followed later by spillover from soot blower action. Also, the nozzle or deflecting action of pairs of tubes is of special significance when tube rows are staggered. Even with units designed for safe velocities, the possibilities for erosion are greatly increased by higher than design velocities resulting from operation at excessive overloads, or with poor firing or setting conditions that result in gas flows higher than should be required.

In conclusion, the authors suggested velocities between and across tubes up to 60 ft per sec with pulverized bituminous coal; 45 to 50 ft per sec as safe values for pulverized anthracite; and 60 ft per sec for spreader stoker firing. With armored surfaces, such as the cast-iron extended type, velocities up to 80 ft per sec with bituminous coal and 65 ft per sec for anthracite had been found acceptable. When the gas flow is parallel to the tubes, velocities approximately 70 per cent higher than those mentioned are permissible.

Discussion

In the discussion of the papers on fly-ash erosion it was brought out that particle size, so far as is known, is not a major contributing factor. Some difficulties have been encountered with large particles and also some very serious problems have been experienced with those of minus ten microns. The errosive effect

of large-sized extraneous ash as contrasted to inherent ash is not fully understood and requires further investigation, as does the influence upon erosion of the size of coal that is fed to spreader stokers. While the papers presented considered primarily mechanical action, it was pointed out that chemical action must be considered as a part of the fly-ash-erosion problem. With spreader stokers the increase in efficiency resulting from reinjection must be balanced against the heavy dust loadings and possible erosion troubles that are often encountered. It was suggested that the addition of heat-recovery equipment might more than compensate for the efficiency gained by reinjection and avoid the problems of erosion and excessive stack discharge.

Central Plant Coal Handling

In a paper entitled "Coal Handling for Central Power Plants," **F. W. Kaercher** of the Link-Belt Co. stated that coal handling is not a constantly changing art but one for which equipment has been designed over the years to meet gradually changing requirements. Steam cranes, flight conveyors and bucket elevators were used in early central power plants and were followed by skip hoists and cable cars to distribute coal to bunkers. The pivoted bucket carrier, which has been used for more than 50 years, continues to have as low an operating cost as other types of elevator and conveyor equipment between the capacity limits of 50 and 300 tons per hour.

Within the past five or six years the bulldozer and carry-all have found increasing use in handling large tonnages of coal in and out of storage areas. They have the ability to reduce fire hazards by their uniform spreading and packing action. For unloading coal cars the rotary dump and car shaker are available. The former is capable of unloading more cars in a given period than can be emptied into a number of track hoppers and requires fewer men. The rotary dump is economically justified where railroad cars must be handled at rates in excess of 350 tons per hour with non-freely flowing coal. At lower rates the car shaker, which is normally suspended from a hoist and lowered to the top of the car, is useful, it being capable of emptying cars in from one to seven minutes.

Bradford breakers and crushers are installed in many conveying systems. They are useful for primary crushing of run-of-mine coal and for the removal of foreign matter.

For medium-sized plants the overlapping pivoted bucket carrier is the most applicable type of conveying equipment as it is capable of handling both coal and ashes. The skip hoist is well adapted to high lifts and to large or small tonnage capacities per hour. Belt conveyors are also extensively used where large capacities are to be handled and high lifts are encountered. There is some difference of opinion concerning the relative merits of enclosed and open-type bridges for belt conveyors.

One result of poor coal quality has been an increase in the maximum angle of coal chutes. While a few years ago the accepted angle for chutes handling fine coal was 45 deg, it is now necessary to go as steep as 70 deg or more in order to insure proper flow.

For supplying stokers the traveling weigh larry and side car carrier find use. Weigh larries vary in capacity from 1000 to 20,000 lb or more, depending upon conditions of service. Where it is desirable to receive material from bin openings at several points and where head room is limited, the side car carrier is useful.

Mr. Kaercher concluded by urging that in selecting mechanical coal handling equipment provision be made for liberal reserve ground storage, ample bunker capacity and accessibility of equipment for future increases in capacity.

Cleaning Coal

Defining the cleaning of coal as the practical reduction and retention at the mines of materials having low combustible content, **Thomas F. Downing, Jr.,** of the Philadelphia Electric Co. discussed techniques of mining operations necessary to produce clean coal. There are economic limits to the amount of preparation that may be justified, and the coal producer must determine answers to such questions as these:

Can I meet competition without mechanical cleaning? What sizes and percentages of output require preparation? What is the cheapest mechanical appliance for the job? Will the cleaned product be suitable for new uses?

Coal impurities having little or no combustible include sandstone, slate, fire clay, shale, pyrite, bony coal, and capillary moisture. While all are rarely found in one coal seam at one location, it is common to find several when two or more seams are prepared over a common tipple. For many years all bituminous coal was cleaned at the working faces, but with increase of mechanized mining most coal today is cleaned outside of the mines. The rapid growth of mechanical loading in recent years has reduced operating costs for mine owners but presents a serious setback to clean coal.

Mr. Downing cautioned that extraneous moisture should be properly evaluated. "If ash be reduced 2 per cent by washing," he said, "the Btu will positively show an increase on a dry basis. However, if 2 per cent moisture has been added, the received (as fired) Btu will most probably be less, certainly not more, than if the coal had not been cleaned. . . . As cleaning by wet methods is increasing, it may be well to assign standards of value for moisture, particularly when fine sizes are used."

The impurities mixed with coal are generally denser than coal and therefore lend themselves to cleaning by air or by any of several flotation processes. To be satisfactory for the coal consumer it is essential that mechanical cleaning produce a consistent product. One point to remember in storing coal is that washed coal which has been dried picks up moisture from the air or from rain more readily than coal in its natural state.

Discussion

Much of the discussion on Mr. Downing's paper centered on the moisture content of coal. Investigations have indicated that coal while in storage does not obtain its moisture so much from rain as from moisture in the air. Moisture penetration rates on the side of the pile exposed to prevailing winds have been found to be noticeably greater than on the lee sides. On the subject of drying coal at the mine it was stated that this

is now carried out with some slack coals and that as more stringent stream contamination laws are enacted, there will be a demand for more coal to be dried at the source of supply.

Recent experiments with coal chute materials were reported in the discussion of Mr. Kaercher's paper. As a chute lining material stainless steel has proved more serviceable for coal handling than rubber and other materials which have been tried. Some mention was made of new developments for an improved belt cleaner and scraper for use with conveyors handling coal fines and fly ash.

Metals in High-Temperature Service

In a paper entitled "Some Engineering Problems Associated with Metals in Elevated Temperature Service," **F. G. Sefing** of the International Nickel Company, Inc., mentioned several properties of metals at elevated temperatures which do not always receive proper consideration but which may have serious effects if disregarded. Dimensional changes in relatively complicated designs of metal pipe and heavy equipment may set up stresses which are enough to distort permanently the original dimensions or to cause rupturing or cracking of some of the parts. When such changes are restrained by design, supports or other devices, stresses may be developed in direct proportion to the design stiffness. Thermal stresses at elevated temperatures are also in direct proportion to temperature changes, stiffness and expansivity, and they can be transmitted to stress concentration points of the design.

At elevated temperatures permanent changes in metal structure sometimes occur. Certain steels in service for more than five years at 850 F to 950 F have undergone sufficient change so that they no longer have their original physical properties when cooled to room temperature. An outstanding example is the graphitization and accompanying permanent embrittlement of welded zones of some steels in 850 F to 1000 F steam piping service.

Metals satisfactory at room temperature may deteriorate rapidly in heavy duty service at elevated temperatures. It is advisable to make careful studies of physical properties necessary at those temperatures and to draw up specifications accordingly. Closer cooperation between mechanical and metallurgical engineers may prevent many of the service failures now encountered.

Pressure Vessels

Engineers from Babcock & Wilcox Company presented a series of three related papers on the fabrication, testing and design of pressure vessels. These reports are a part of a cooperative research program sponsored by a number of manufacturers interested in investigating the possibility of operating pressure vessels at stresses in excess of those presently allowable in applicable codes.

O. R. Carpenter outlined the steps taken from the initial design of a pressure vessel to its actual fabrication in his paper entitled "The Fabrication of Pressure Vessels." As stresses are carried beyond present levels, increasing attention must be given to finish and workmanship. Slight surface defects may set up serious localized stresses, and notches, which may have a very bad effect, should be removed to insure smooth stress flow. Residual stresses resulting from fabrication should be avoided wherever possible or relieved by the methods generally available in fabricating shops. Also, types of openings that minimize residual stress should be used whenever possible. With the increasing use of dissimilar metals, such as in welding headers to the drum, new problems of high differential stresses are encountered. In all cases inspection and quality control of component materials play an important part in pressure-vessel fabrication.

"Experimental Technique in Pressure-Vessel Testing" was the topic of a paper by **L. F. Kooistra** and **R. V. Blaser** who described methods to measure the stress on both the inside and outside of full-sized pressure vessels. SR-4 electric resistance strain gages were employed for much of the test work, for which transformer oil was used as a pressure medium. A special electrically insulated, pressure-tight plug was designed to bring the gage wires through the shell of the vessel. Fatigue tests were conducted at one and one half times working pressure instead of static-pressure destruction tests, because the former more closely simulate actual operating conditions. One run consisted of 100,000 cycles, after which the specimen boiler drum was carefully inspected visually and magnetically. These tests were carried on both at room temperature and at conditions approximating operating temperatures. Data obtained are expected to aid in designing pressure vessels to avoid excessive stress ranges over the maximum pressure cycle.

G. J. Schoessow and **E. A. Brooks** presented the third paper entitled "Analysis of Experimental Data Regarding Certain Design Features of Pressure Vessels." The stress situation of vessels of complicated shape subjected to internal pressure is not readily explained by simple membrane stress concepts. Deviations from a true membrane shape set up bending in the vessel wall and cause direct loading to vary from point to point. An idea of how a vessel behaves under pressure may be obtained by plotting actual loads and moments which are experimentally determined from the vessel, as set forth in the preceding paper by Messrs. Kooistra and Blaser. When an internal pressure is applied, the direct loading is diverted from the more flexible to the more rigid portions of the vessel, and bending takes place in the shell.

Discussion

In the discussion of the three papers on pressure vessels the effect of equipment codes in restricting the designer was considered. There appeared to be agreement that, while codes sometimes did have an adverse effect upon design, they generally did not restrict it very much. Experimental techniques of testing were the subject of some questioning, although it was admitted that some of the physical constants were not known to a degree of certainty warranting very fine refinements in technique. Methods of testing pressure vessels under laboratory conditions duplicating what may be expected in the field have a long way to progress before a satisfactory theory of vessel failure may be developed.

Facts and Figures

The deepest oil producing well in the world is located in Kern County, Calif., and is nearly 3 miles deep.

•

In an air heater the drop in gas temperature is always less than the air temperature rise, usually in a ratio of about 1 to 1.25.

•

High-velocity steamjets should never be placed so that they scrub the furnace walls.

•

Carbon dioxide and water vapor are capable of absorbing heat by radiation and of radiating heat to colder surfaces.

•

A pound of coal burned in a modern central station and converted into electricity will keep a 100-watt electric light burning for more than 8 hr.

•

Late figures on average heat consumption of central power stations in Great Britain show an average of 16,400 Btu per kwhr sendout.

•

Rate of flame travel depends upon the gas-air mixture with minimum speed occurring at both the lower and the upper mixture limits, and maximum speed at some intermediate point.

•

According to Bituminous Coal Institute, the average hourly earnings of bituminous coal miners for the year 1948 was $1.899, which figure was approximately double that of 1941.

•

The chemical composition of a refractory cement should be related to the refractory brick with which it is used in order to avoid the possibility of chemical action that may weaken the bond.

•

Where pitting and corrosion of boiler metal occur, black deposits usually indicate the presence of magnetic oxide of iron (Fe_3O_4) and dark red deposits, ferric oxide (Fe_2O_3).

•

Black liquor is a residue that results from the conversion of wood into pulp by the sulfate process. As fired it has a moisture content of about 35 per cent and a heating value of about 6500 Btu per lb.

•

More than $2^1/_2$ million kilowatts of generating capacity in the United States is now operating on the resuperheat cycle. This is exclusive of that under construction.

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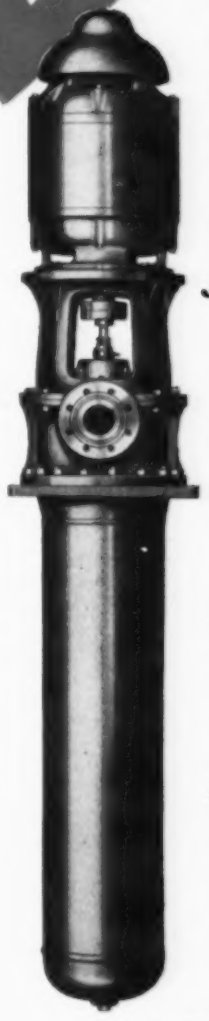

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CLEVELAND 13
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D. C. Murphy Co., Inc.
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DETROIT 16
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KANSAS CITY 6
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C. F. Saxton
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Halladay & Knauff
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Humphrey-Wynne Co.
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NEWARK 2
Koithan & Johnson
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NEW ORLEANS 12
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NEW YORK 7
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OMAHA 2
Wain Engineering Co.
415 Brandeis Theatre Bldg.

PHILADELPHIA 2
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PITTSBURGH 22
H. Lee Moore
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Arthur Forsyth Co.
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R. D. Moyer
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Chas. W. Lockhart
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J. W. Cooper
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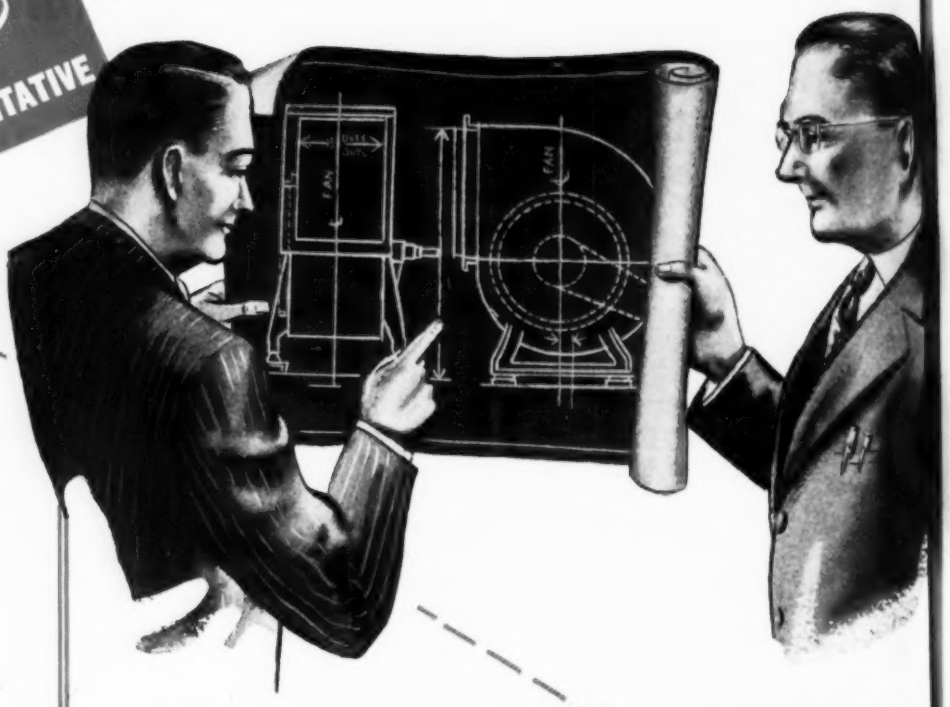
Call in your nearest "Buffalo" Representative—his "Air Know-How" is at Your Service

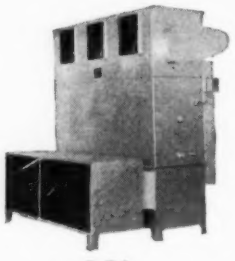


READY AND COMPETENT
to work with your consulting engineer
ON YOUR AIR PROBLEMS

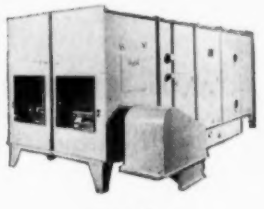
To make your investment in air pay you maximum dividends, it's more than a matter of buying a *good* fan or a *good* air conditioning unit. In today's complex air handling problems, proper selection of equipment is often the only answer—plus an effective *link* between your own engineer and the firm supplying the equipment.

This is one of the reasons why "Buffalo" installations have been so satisfactory to users. "Buffalo" equipment, a complete line of field-proven fans and air conditioning units—*plus* the "Buffalo" representatives at left—give you this ideal combination.

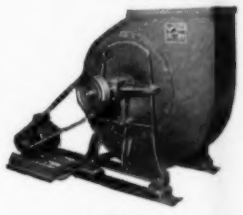
"Buffalo" representatives know their equipment and the jobs it is designed to handle. They are Graduate Engineers with one to five years of factory training, in addition to wide field experience. And they have all the resources of the "Buffalo" home plant engineering staff to back them up.



Buffalo Air Conditioning Cabinet



Buffalo Air Washer



Buffalo Limit-Load Fan

FIRST FOR FANS

BUFFALO "Buffalo" FORGE COMPANY

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VENTILATING FORCED DRAFT | AIR WASHING COOLING | AIR TEMPERING HEATING | INDUCED DRAFT EXHAUSTING PRESSURE BLOWING

Design Trends Discussed Before Electrical Engineers

"Trends in Modern Generating Stations" was the subject of a paper by Ralph C. Roe, president, and R. F. Cummings, chief engineer, of Burns & Roe, consulting engineers, before the A.I.E.E. Power and Industrial Division in New York on October 4.

In presenting the paper, Mr. Cummings discussed measures for offsetting high material, labor and fuel costs. These include a more or less standardized design for a given capacity, involving less cubic volume per kilowatt of capacity, mounting the turbine on the condenser to save a separate foundation, boilers adapted to the burning of a wide range in fuels, centralized and automatic controls to minimize labor, and the employment of simple electrical equipment that can be factory assembled. Economy in space, he pointed out, not only saves in building construction but also in piping, and the high cost of brick laying has in some instances brought about other forms of construction.

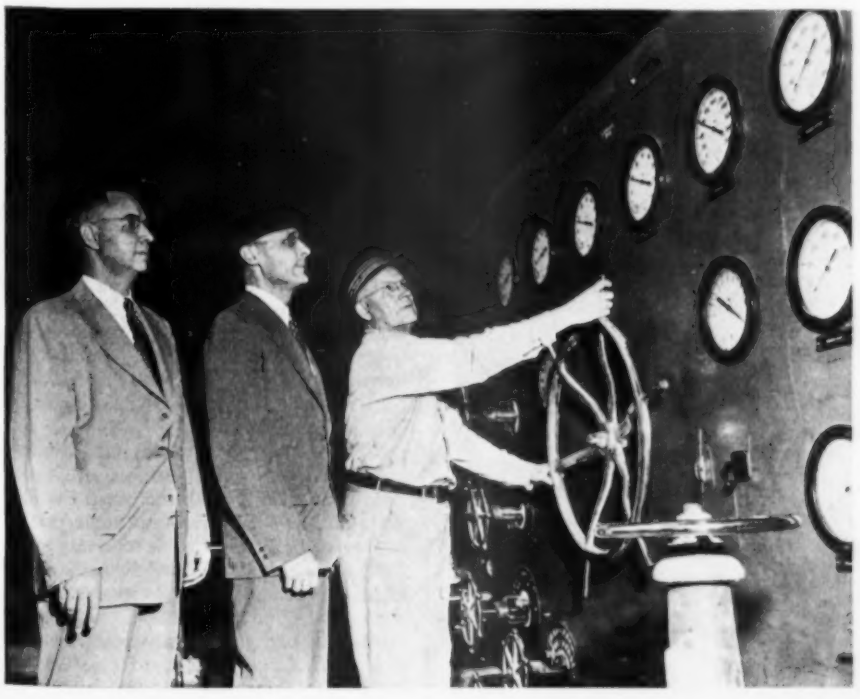
Since most utilities are faced with the 40-hr week, there is a trend in design to eliminate as much as possible the necessity for week-end maintenance work.

Design factors aimed at improved efficiency to offset high fuel costs include high steam pressures and temperatures, reheat, and an increased number of bleed points for feedwater heating. In this connection the speaker predicted that, although the cost of certain alloy steels had heretofore been a deterrent, a greater number of plants would probably adopt 1050 F or perhaps 1100 F total steam temperature. Even the latter figure may be exceeded as experience is gained. The increase in the single-turbine, single-boiler arrangement favors the reheat cycle which in some instances reported is claimed to cost little more than the straight regenerative cycle.

Other points stressed by the speaker were a simple coal-handling system comprising a bulldozer, belt conveyors and cylindrical bunkers; the high availability of the modern steam generating unit; and the trend toward all-motor drive for auxiliaries. He also reviewed some of the work to date in adoption of pressurized furnaces to eliminate induced-draft fans, features of the cyclone furnace, as well as tilting burners and other means of securing uniform steam temperature. He believed that a combination of the steam and gas turbine cycles, such as has been applied at the Huey Station of the Oklahoma Gas & Electric Co., has many possibilities.

Fourth Unit in Operation at Port Washington

In the accompanying photograph W. A. Yost, manager of Allis-Chalmers steam-turbine department, and C. F. John, vice-president of the Wisconsin Electric Power Co., watch while Harry Shaver, engineer-in-charge of the utility's Port Washington (Wis.) power plant opens the throttle valve during starting operation prior to synchronizing the new No. 4 turbine unit for the first time. This is the fourth unit to be installed in this station. All are Allis-Chalmers 80,000-kw reheat machines supplied with steam at 1380 psig, 900 F, with reheat to 900 F by Combustion Engineering pulverized-fuel fired boilers. A fifth turbine-generator and boiler of like design are building for installation in 1950. This station was one of the first to use the now-accepted one-boiler-per-turbine arrangement and it has consistently had one of the lowest station heat rates in the world.



Coal Operators and the Railroads

Speaking before the Annual Convention of the Railway Fuel and Traveling Engineers Association at Chicago, on September 22, J. E. Tobey, president of Appalachian Coals, Inc., discussed the interdependency of the coal and railway industries, with particular reference to the suspension in coal mining which has been responsible for the layoff of some 28,000 railroad employees.

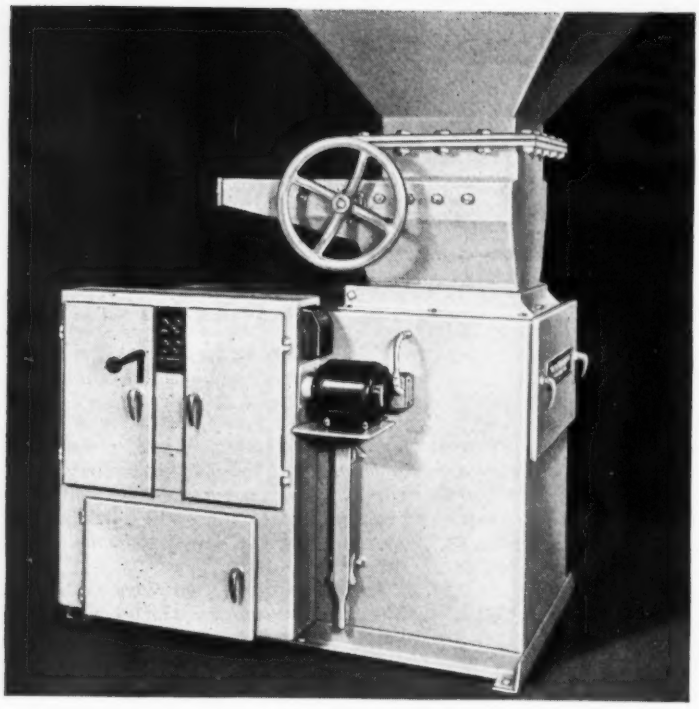
In 1948, steam locomotives used about 88 million tons of coal which has for some years been predominantly run-of-mine and nut slack—sizes that were not in great demand by industry or for domestic use. However, this condition Mr. Tobey sensed as changing as a result of the rapid expansion of pulverized coal firing in stationary power plants, which are better adapted to use of fine coals than are the mobile power plants of the railroads with locomotive firebox limitations and the high combustion rates employed.

"Today's larger and more powerful steam locomotives," he said, "have relatively smaller fireboxes than their earlier prototypes, and they require drafts of hurricane velocity which carry a much higher percentage of fine coal out the stack. In fact, under heavy load conditions some locomotives, when burning run-of-mine or nut and slack, discharge as much as 35 per cent of the coal fired out the stack practically unburned."

For some time the railroads have been experimenting with double-screened coal (mostly 4 × 1¼-in.) on their locomotives, and tests have indicated the value of these sizes for such use. In fact, the L & N reported a saving of 10.85 per cent over a five-month period through more adaptable coal selection. However, Mr. Tobey was of the opinion that, in order to procure sufficient tonnage, the railroads may have to be satisfied with a larger top size.

As a result of the cooperative research backed by the railroads and the coal industry and carried on by Bituminous Coal Research, Inc. and the Locomotive Development Committee, two pulverized-coal-fired gas-turbine locomotives are under construction and experimental work on gas producers for similar locomotives is being conducted. Also, a large 600-psi coal-fired steam road locomotive with a water-tube boiler is on order, as are four large steam-electric locomotives of advanced design.

Finally, it was pointed out that there has been considerable improvement in coal quality since the war, which improvement has been particularly noticeable within the last year. This is attributable both to the retirement of marginal mines and to improvements in mechanical mining methods and cleaning equipment.

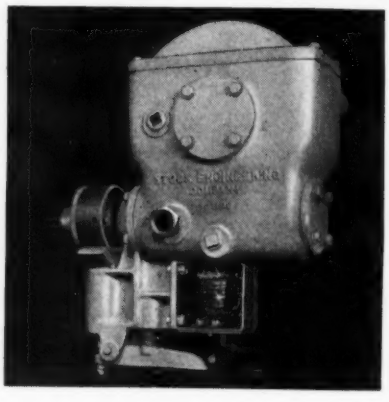


HUSKY GEARS AND BEARINGS ASSURE LONG LIFE

# of S-E-CO. COAL SCALES

S-E-Co. Coal Scales are designed with the idea that the gears and bearings of each scale will last as long as the boilers to which coal is being fed. Experience with these items over a 10-year period indicates that the design calculations are correct. To date no gear has ever worn out on a S-E-Co. Coal Scale.

If you want a coal scale which will have long life with a minimum of maintenance, investigate the S-E-Co. Coal Scale.



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STOCK ENGINEERING COMPANY
715C Hanna Building ★ Cleveland 15, Ohio

Bureau of Mines Reports on Coal Research

Diversified research on coal by the U. S. Bureau of Mines last year showed additional coal reserves in several states, stretched the Nation's supply of coking coal by developing blends, improved the techniques for producing synthetic liquid fuels, and afforded savings in the purchase of Government fuel supplies.

To assist consumers in fuel-short areas, core drillings were made in the Pacific Northwest that proved a reserve of 13,600,000 tons of minable coal in Oregon and reserves of more than 8,000,000 tons of lignite in Washington, of which 5,300,000 are considered minable by stripping methods. Investigations of coal deposits also were carried on in Rhode Island, Colorado, Maryland, North Carolina and Alaska.

To augment the depleted reserves of coking coal, investigation was made of methods of up-grading coals by removing undesirable constituents and methods of utilizing low-grade coals by blending with better coals.

As a result of laboratory research and pilot-plant experimentation on the production of synthesis gas and on the synthesis of liquid fuels from such gas, an 80-to-100 bbl per day demonstration plant was designed and construction was started at Louisiana, Mo. A 200-to-300 bbl per day coal hydrogenation demonstration plant at Louisiana neared completion at the end of the fiscal year and was placed in operation shortly thereafter. New laboratories housing synthetic liquid fuel research were opened at Bruceton, Pa.

In rendering service to Federal agencies on fuel and equipment purchases, the Bureau tested more than 6800 coal samples and analyzed approximately 6300 additional samples of coal and coal products. Its fuel engineering service resulted in considerable savings in operating costs, particularly at Army and veterans' hospitals. Nearly 8200 boiler-water samples from Government boiler plants were analyzed and chemicals and methods for controlling intracrystalline cracking in boilers were developed.

Plans were outlined to follow up the initial experiment on the underground gasification of coal in Alabama with a second field-scale test. Seven experimental runs were made on a laboratory-scale retort built to duplicate as nearly as possible some of the conditions encountered in actual underground gasification.

Increased interest in recovering more coal in processing led to the commercial adoption of a new cleaning and dewatering process for fine-size coal. Further refinement of a cyclone washer afforded easier recovery of fine coal and clarifying of washery water.

Cooperating with industry, the Bureau developed a method of storing sub-bituminous coal safely and compiled considerable data on the safe storage and transportation of lignite. The development of a flash-drying process for efficient removal of excess moisture from subbituminous coal and lignite offers promise of increased utilization of these low-rank fuels.

Copies of the report, Information Circular 7518, may be obtained by writing

to the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pa.

Power in Eire

A high-spot review of power in Eire was given in a recent paper before the Institution of Civil Engineers and reported in the August 12 issue of *Engineering* (London).

Inasmuch as Eire has practically no natural coal resources and imported coal is expensive, much dependence is placed on hydro power, peat, and to some extent, imported oil. Approximately 69 per cent of the total energy requirements up to the present have been provided by water power, which will shortly be expanded to a total of 206,000 kw. The largest existing hydro development is of 80,000 kw on the River Shannon.

Seasonal variations in flow, however, make steam plants a necessity. At present the largest steam station, located in the vicinity of Dublin, has a capacity of 95,000 kw and another of 180,000 kw ultimate capacity is projected. Also, in the same vicinity a new oil-burning station of 25,000 kw has recently been started up.

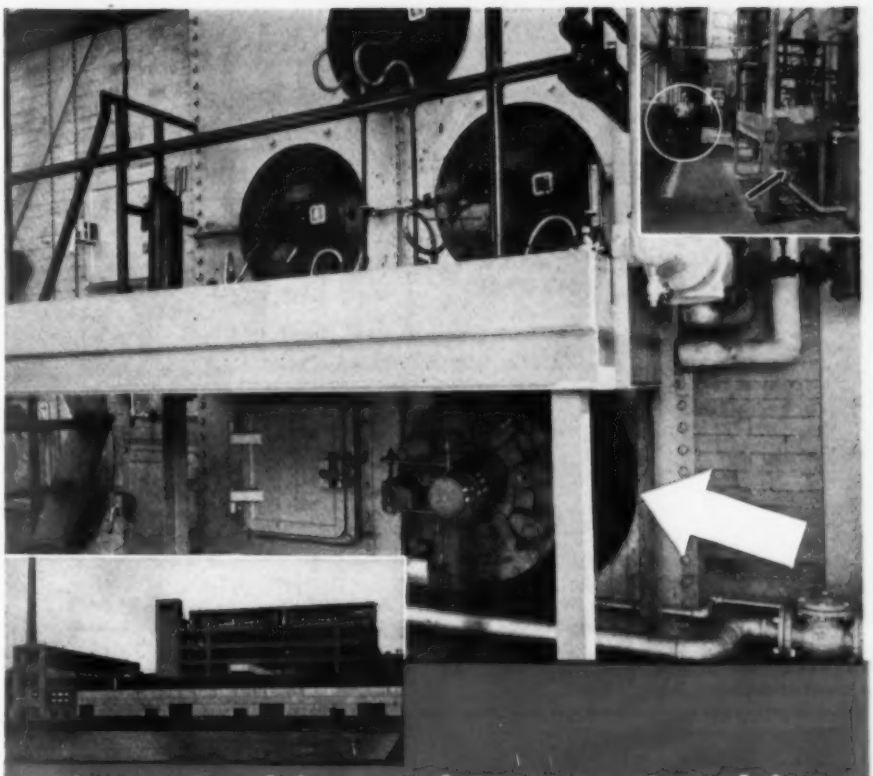
Peat has long found domestic use in Eire and to some extent in gas producers, but, despite extensive deposits, large-scale utilization of peat as a fuel for electric generating stations has not heretofore been attempted. However, two such stations are now under construction—one at Allenwood of 40,000 kw initial and 60,000 kw ultimate capacity, and the other at Portarlington of 25,000 kw initial and 37,500 kw ultimate rating. They are scheduled to go into service in 1951.

Omission of the Degree

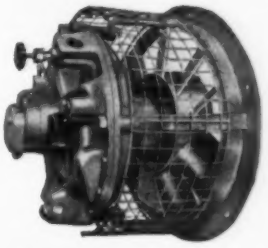
I wish to compliment you for your editorial "Omission of the Degree" in the August issue. I assume that you purposely ended this editorial in a question mark as a challenge to the reader. Instead of just answering this question to my own personal satisfaction, I would like to take the liberty of writing my answer.

You have set up three classifications for the omission of the initials "P.E.," (1) modesty, (2) lack of appreciation of a degree, and (3) indifference. Undoubtedly a great many registered engineers will fall into some one of those classifications. Some of them, unfortunately, will fall into all three categories.

In regard to the second reason "lack of appreciation" and the third reason "indifference," I think that the feeling behind these is the lack of public appreciation that engineering is a profession. And where should the blame be placed that more of the public does not regard the registered engineer as a professional engineer? On the public? No sir, the responsibility boomerangs right back on the engineer. If more registered engineers would conduct their businesses and their private lives like professional men, then a greater percentage of the public would regard us as professional engineers and not merely registered engineers. It is my belief that just because an engineer quali-



Wing Turbine Blowers Combine Absolute Dependability With Complete Forced Draft Efficiency



Shown above is a typical Wing Turbine Blower installation serving one of the world's largest coffee packing plants. Note that the engineer (upper right photo) is able to talk on the telephone a few feet away from the Wing Turbine Blower—ample proof of its quiet operation. Write today for Bulletin.

In addition to these prime requisites, Wing Turbine Blowers have many extra money saving features including minimum cost of operation, simple, rugged, and compact construction, and because little or no duct work is required, no time and expense is required for engineering layout. Where plants can make use of the low pressure steam from the Wing Turbine Blower for such uses as feed water heating, process work, or space heating, the forced draft is obtained at negligible cost.

L. J. Wing Mfg. Co. 54 Seventh Avenue, New York 11, N. Y.
Factories: Newark, N. J. and Montreal, Canada

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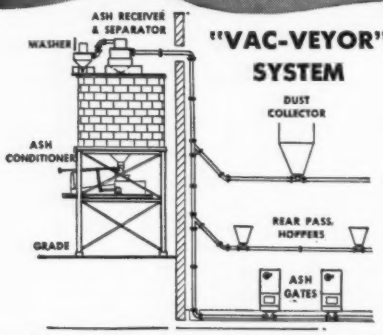
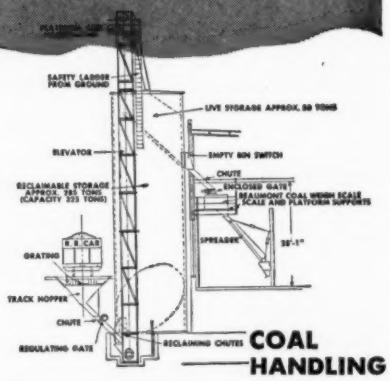
AXIAL FLOW BLOWERS

Profits Saved AT EVERY STAGE . . . WITH BEAUMONT COAL & ASH HANDLING EQUIPMENT



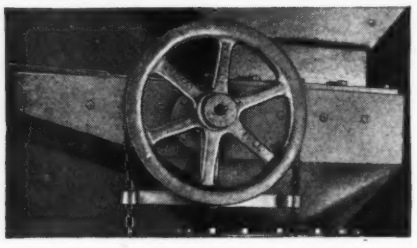
"VAC-VEYOR" SYSTEM

In this system, ashes, siftings, soot and dust are conveyed by pipe from the ash pits, dust collectors, stack, etc., to an ash receiver and separator at the top side of a silo—by means of a vacuum. One man operates the system, keeping your plant cleaner with less labor.



COAL HANDLING

Coal arrives by rail, is dumped into hopper, raised by bucket elevator and discharged either into bunker for immediate use or down chute to yard storage. One operator controls all equipment.



ROLLER BEARING GATE

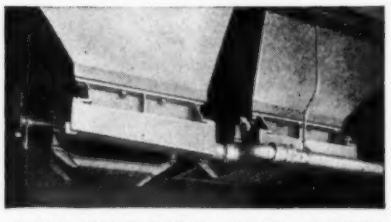
Incorporating double rack and pinion for granular or powdered materials, these drip-proof self-cleaning gates will not corrode, bend or warp. Material cannot collect in back of gates—these ball bearing gates operate manually or electrically without strain or ramming.

AUTOMATIC WEIGHING SCALE

Accurately weighs coal and similar materials from 1 to 60 tons per hour. Vibrating feeder plate eliminates belts, pulleys and motors. Scale is totally enclosed, dustproof and quiet.

DRAG SCRAPER SYSTEM

Coal is dug evenly with minimum power consumption. Tail blocks can be slung between posts and moved by hand, mechanically moved on I-beam track by tail block car, or suspended from aerial bridge system. One man can operate entire system by remote control.



ASH HOPPERS AND GATES

Steel plate ash hoppers are low cost, rigid, unbreakable, watertight and, when lined with refractory material, resist temperature and erosion. Ash gates are designed for use on stoker and pulverizer ash hoppers where water sealing and draining is essential.

Beaumont engineers design and erect this and associated equipment—*a complete coal and ash handling system.* You save in installation as well as in handling. ONE CONTRACT—ONE RESPONSIBILITY—FOR BULK HANDLING SYSTEMS. Write for more information to:

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Designers Manufacturers Erectors BULK MATERIAL HANDLING SYSTEM

fies for and is given a certificate to practice professional engineering, he is merely a registered engineer until he becomes a professional man in the eyes of his colleagues and the public.

FREDERICK B. MORSE, P.E.
West Lafayette, Ind.

Obituary

Edgar R. Crofts, vice president of the Rochester Gas & Electric Corporation, died in Rochester on September 9, following a brief illness, at the age of 61.

Becoming associated with that company more than 30 years ago, Mr. Crofts advanced through various positions to that of vice president in charge of engineering and various operations of the company.

Business Notes

De Laval Steam Turbine Co., Trenton, N. J. has appointed C. C. Bray regional supervisor of the new Midwestern District Office recently opened by its IMO-De Laval Products Div. It is located at 1500 South Western Ave., Chicago 8, Ill.

Cochrane Corporation, Philadelphia, has appointed S. B. Appelbaum manager of its Cold Process Water-Treating Division. He is also vice president of the Liquid Conditioning Corporation, an operating subsidiary of Cochrane.

Poole Foundry & Machine Company, Baltimore, Md., announces the election of Lawrence M. Ricketts, Jr., as vice president and assistant treasurer.

Graver Water Conditioning Company has removed its general offices from Chicago to larger quarters at 216 West 14th Street, New York 11. This company is a division of the Graver Tank & Mfg. Company of Chicago.

Edward Valves, Chicago, on September 16 and 17, held open house in celebration of the opening of its new chemical, physical and metallurgical laboratory.

Buffalo Pumps, Inc., Buffalo, N. Y., announces the election of Henry D. Wilson and Bruce W. Ellis to its board of directors. Mr. Wilson is manager of the Company's factory and Mr. Ellis is chief engineer.

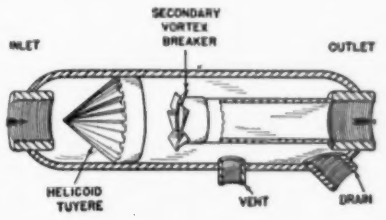
Fairmont Coal Bureau has appointed Donald M. Given, Jr., as fuel engineer to concentrate on better engineering for the small steam plant.

Combustion Engineering-Superheater, Inc. has appointed Forney Fuller as a contract salesman assigned to its Birmingham office, and Henry C. Schatz as maintenance salesman assigned to its Charlotte, N. C. office.

NEW EQUIPMENT

Air-Steam Line Purifier

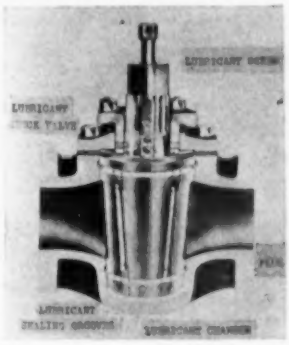
A new purifier known as Type RA to remove oil, water, pipe scale and sediment from compressed air and steam lines is announced by the Centrifix Corp., 3029 Prospect Ave., Cleveland 15, Ohio. The unit has a new type helicoid tuyère constructed of monel or stainless steel to effect separation of entrainment. Among the



uses for the purifier is service as a conditioner for compressed air on air drills and sandblast machines, and to remove moisture from process steam in the food industry. Designed for use in either horizontal or vertical downflow position, the purifier can be used on steam lines up to 400 psig, 650 F and on compressed air lines not exceeding 800 psig, 100 F in non-shock service.

Plug Valve Lubricant

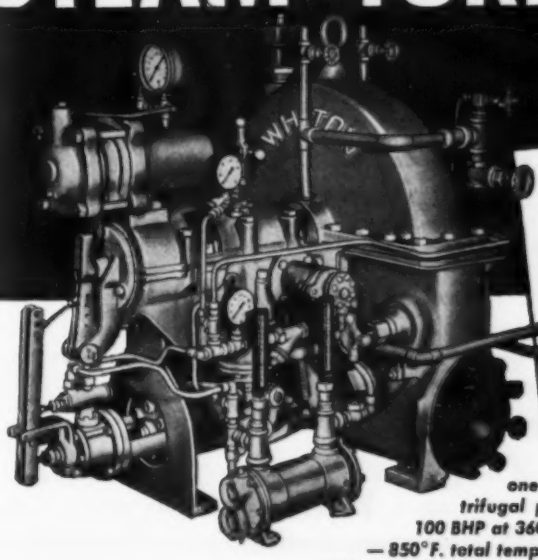
The Nordstrom Valve Division of the Rockwell Manufacturing Co., 400 N. Lexington Ave., Pittsburgh 8, Pa., has developed a new liquid, known as "Hypermatic," for automatic lubrication of pressurized plug valves. The force-feed action of the new lubricant is said to seal the void in case of leakage in a lubricated plug valve. Lubricant is introduced into the valve through a hole in the shank of the



plug. Sticks of lubricant are dropped into the hole and a screw is inserted which exerts a force to transmit the lubricant through the channels. The "Hypermatic" fluid, which is said to be volumetrically flexible, self-sealing and self-acting, serves to effect automatic action in the plug valve. The lubricant has an operating range of pipe line temperatures from subzero conditions to at least 250 F.

Whiton SOLID STEEL ROTOR

STEAM TURBINES



Available in single stage types up to approximately 1200 HP rating. Center supported frames are available when required.

Turbine shown above is one of 24 ordered to drive centrifugal pumps designed to deliver 100 BHP at 3600 rpm with steam at 850# — 850°F. total temperature exhausting against 42# gauge back pressure.

• SIMPLE DESIGN FOR ACCESSIBILITY

Inlet and exhaust connections are located in lower half of casing which is horizontally split to allow easy access to all internal parts. Rotating unit including bearings and governor head may be removed without disturbing alignment of the unit.

• RUGGED CONSTRUCTION FOR RELIABILITY

Whiton rotors are made from a solid steel forging with semicircular buckets milled in the rim to give strength where it is needed. End thrust is minimized because the path of the steam is always at right angles to the shaft.

• SAFETY DEVICES FOR TROUBLE-FREE OPERATION

Standard equipment includes Constant Speed Governor with V-Ported Governor Valve . . . Emergency Governor with Independent Valve . . . Steel Plate Steam Strainer . . . Two oil rings per bearing supplemented by water cooling . . . Sentinel Type Casing Relief Valve . . . Additional accessories available as required.

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Combustion Safeguard

The Bristol Co., Waterbury 91, Conn., has developed a new combustion safeguard known as the "Electronic Pyrotrol" which protects gas-fired furnaces, ovens, kilns, boilers and industrial heating equipment from danger of gas explosions during ignition, operation and shut off. If normal operation fails, the lighting-up cycle stops and closes any valve that has opened. In case of power supply failure the entire system is shut down in a safe manner. The control instrument uses commercially available cable for connections and does not require selected electronic tubes. It is offered in six models to take care of various requirements.

Instrument Valves

Edward Valves, Inc., East Chicago, Ind., is offering new forged steel instrument valves designed to fit into limited space and to withstand pressures as high as 6000 lb. Constructed of carbon steel, 13 per cent chromium steel, or 18-8 stainless steel, these valves are available in globe or angle design in ¼-in., ⅜-in., and ½-in. sizes with screwed or socket welding ends. They are suitable for providing close regulation on orifice meters, regulator lines, gage lines, instrument panels, pumps, and bypass lines. Those built of stainless steel are quite useful for steam sampling lines where it is essential to avoid contamination.

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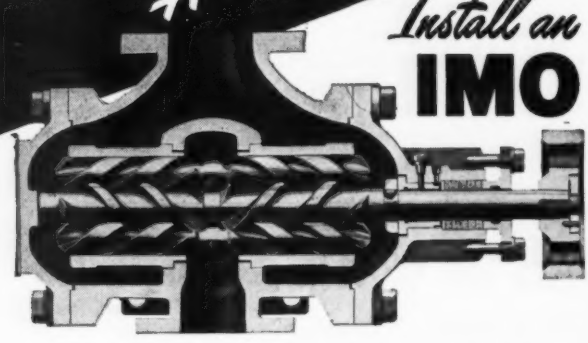
Install an IMO



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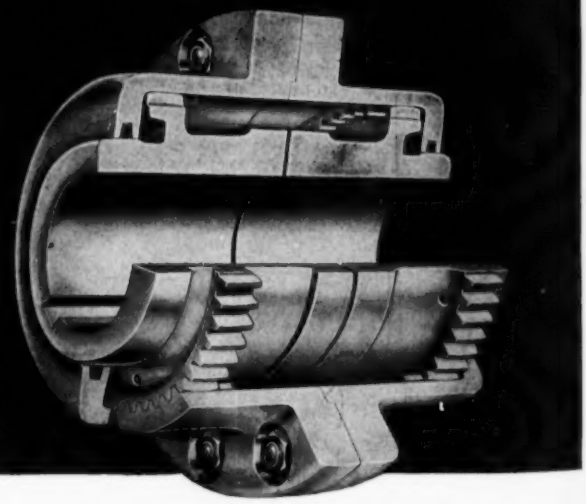

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REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Fundamentals of Power Plant Engineering

By George E. Remp

The author, who is assistant professor of mechanical engineering at the University of Florida, has adopted a sequence of presentation that is quite different from that of most textbooks. Starting with a study of load curves, followed by the economics of power production, vapor power cycles and heat balances, he then proceeds to consideration of the various items of equipment that enter into a power plant. This logical approach simulates that which the student is likely to encounter later in practice. The treatment assumes familiarity with the fundamentals of engineering thermodynamics but is not too technical.

Numerous problems are included as well as their solutions, and the text is adequately illustrated. The appendix contains much useful data and a reproduction of the Combustion Engineering-Superheater steam tables.

Instead of being printed the pages are offset from typescript; but the reproduction of some of the illustrations and diagrams leaves much to be desired as to clarity. This is unfortunate in view of the excellence of the subject matter.

There are 347 pages, $5^1/_2 \times 8^1/_2$ in. and the price of the book is $6.50.

Steam Power Plants

By Philip J. Potter

This addition to the list of college textbooks covering the heat-power field is characterized by an unusually detailed presentation of fundamental theory without loss of practical attention to the present state of the power plant art. It also ranks among the best-illustrated books of its type, not only from the point of view of the selection of photographs, diagrams and curves, but also as an example of their excellent reproduction.

Following an introductory chapter the author undertakes an exposition of Flow of Fluids, a chapter which includes an especially intelligible discussion of viscosity along with practical data on piping. Then follow chapters on Pumps, Theory of Heat Transfer, Fuels and Combustion, Steam Generators, Boiler Auxiliaries, Heat-Exchangers, Steam Turbines, Steam Engines, Heat Balances and Economics of Steam Power Plants. Each chapter includes selected problems of the type encountered in power plant design and there is an appendix which contains two design problems on industrial power plant layouts along with typical dimensions and performance curves of representative equipment. The chapter on Steam Generators includes a 16-page account of boiler design, and theoretical considerations relative to steam turbines are discussed in more than usual detail in the chapter on Steam Turbines.

The author's thesis that principles involved in industrial and small power plant design are the same as those for the large central station deserves wider acceptance. Even though the amount of engineering time and study that may go into the former is not as great as for a central station design, the industrial power plant cannot reach the stage of physical construction without the making of essentially the same type of basic decisions required for plants many times larger. It is wise for the student to understand the equipment and methods of the central station because of their all-inclusiveness, but he should not underestimate the complexity of a power plant merely because it does not rank among the largest units or does not employ the most extreme steam conditions.

Practicing engineers will find Professor Potter's book a valuable addition to their technical library because it is well written and effectively illustrated. The intentional omission of chapters devoted to such empirically designed equipment as coal and ash handling machinery and dust collectors is but a minor detraction from the practical value of the book, which contains 503 pages and sells for $6.50.

A Professional Guide for Junior Engineers

By the late W. E. Wickenden, as edited by G. R. Henninger

"I dedicate myself to the dissemination of engineering knowledge, and, especially to the instruction of younger members of my profession in all its arts and traditions."

These words from the "Faith of the Engineer" may be said to keynote the excellent booklet that has been prepared under the auspices of the Engineers' Council for Professional Development, a conference agency of the engineering profession responsible for the professional development of aspiring engineers during the critical ten-year period extending from the middle of high school to what might be termed the completion of "industrial internship." The difficult task of writing concretely about what is essentially an intangible subject, namely, personal guidance based upon a philosophy of engineering, has been accomplished in a manner that commends itself to young and old engineers alike. In fact, the booklet stands as a model of good taste and effective literary style that should arouse interest beyond the bounds of the engineering profession. It also fills a long existing need for a work adaptable to senior-year college courses in professional adjustments and should find extensive use both in college guidance work and among groups of young graduate engineers.

Two philosophies that must be introduced and balanced properly in advising young engineers are realism and idealism. The introductory chapter titled "The Engineer's Heritage" begins on an idealistic note of inspiration from the past. Immediately there follows a "down-to-earth" chapter discussing some of the human qualities that are tested in the transition from student days to industrial endeavor. Then are elucidated some of the decisions and choices which the young engineer must make: size of organization to be joined, training course versus immediate responsibility, industrial teamwork and post-college development. This leads to chapters on "The Engineer and Legal Registration," "Trade or Profession," "What and Why is a Profession?" and "The Engineer in his Professional Relationships."

Problems of the young engineer in his relation to industrial unionism are faced frankly and courageously, recognition being given both to some of the practical realities of union membership during the engineer's training period and to the professional ideal of advancement through personal merit. Privileges and responsibilities of engineers as professional men are explained in terms of public obligation and ethical conduct, and there is an especially provocative exposition of reasons for the engineer to support his professional society. Dr. Wickenden's inspirational essay, "The Second Mile," is a fitting last chapter to supply an idealistic link between technical achievements and lasting human values.

The book is paper-backed, contains 55 pages, and sells for $1.

New German Technical Publication

Some COMBUSTION readers who read technical German will recall the prewar magazines *Archiv für Wärmewirtschaft*, *Die Wärme*, *Feuerungstechnik*, and *Wärme- und Kältetechnik*, several of which were publications of Des Vereines Deutscher Ingenieure, and all of which dealt with the steam power field. Out of these, which were discontinued in the latter part of the war, has arisen a new publication under the title "BWK" which stands for Brennstaff Wärme Kraft.

This new magazine, published in Düsseldorf and edited by Dr. Ing. F. Zur Nedden, VDI, who was at one time well known on this side of the Atlantic, assumes the traditions of the earlier magazines. To quote from the contents of the first issue will give an idea of its coverage. The titles include "Unlocking the Earth's Sources of Energy," "Technical and Practical Principles of Gas Heat," "Fuel Consumption of Steam and Thermo-Electric Locomotives," "European and American Power Plants Compared," "Dependency of Boiler Efficiency upon Age," "Difficulties in Feeding Steam Boilers," "Distribution and Use of Coals in Germany," and "Reports and Discussion on the Provisions for Power in West Germany."

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New Catalogs and Bulletins

Any of these may b secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Arc-Welding Accessories

A new 20-page catalog containing descriptions, specifications and prices of more than 150-arc-welding accessories has been made available by the General Electric Co. The new bulletin includes information on electrode holders, helmets and goggles, tungsten electrodes, all types of protective aids and clothing, electrode carriers, cable connectors, ground clamps, fillet weld gages and many other accessories for the arc-welding operator.

Bulk Weighing Scales

Richardson Scale Co. has issued two new illustrated bulletins describing latest models of automatic bulk weighing machines. Bulletin 1549 gives information on the belt-fed "Class 39" scale, and Bulletin 1449 describes the "Class 40" scale which is designed for optional methods of feed according to the physical characteristics of the material being handled. Each bulletin contains a dimensional plan and elevation drawing of the scale and specifications on capacities, service and available accessories.

Centrifugal Pumps

Construction features of Allis-Chalmers Type S, single-stage, double-suction pumps are described in a 24-page bulletin which carries tables of available sizes, approximate dimensions, and head capacities. There is a useful section explaining how to figure pumping head, and a table of friction losses for water per 100 ft of pipe. Installations using these pumps include filtration and sewage plants, pumping stations, quarries, paper mills, steam power and chemical plants, and on board ship.

Chemical Feed Pumps

Milton Roy Co. has released Bulletin No. 649 describing the "Constametric" pump, a duplex plunger type which incorporates a cam driving plungers to obtain straight-line-flow discharge free from pulsations. The 4-page release includes a list of suggested applications for chemical feed where slug feeding may be objectionable, a table of capacities and pressures, and views of several other types of Milton Roy pumps.

Cleaning Industrial Equipment

A general information bulletin has been released on Dowell Inc. service for clean-

ing steam generating, heat-exchange and other industrial equipment. Also included are data on pipe-line cleaning and water wall acidizing. The bulletin treats in detail methods which are intended to remove incrustations from internal surfaces efficiently and economically with a minimum of downtime.

Chlorinating Equipment

Builders-Providence, Inc., has issued a 4-page bulletin, 840-F2, which describes and illustrates the Model DVS Chlorinizer which is designed to meter chlorine gas and deliver a chlorine-water solution to the point of application. A cutaway view shows the physical arrangement of the components of the Chlorinizer, and a three-color diagram indicates the method of operation. The bulletin also includes discussions of safety features of the chlorine feed apparatus and of the type of construction employed.

Deaerating Equipment

Publication 3005 is a revised 35-page catalog entitled "Cochrane Deaerators" issued by the Cochrane Corp. It combines the latest information on the importance of deaeration to feedwater chemistry with a complete description of modern deaerating equipment. The publication is illustrated with diagrams and photographs of actual deaerator installations and also includes technical data on operation of deaerating equipment, together with an informative article on "The Role of Alkalinity in Preventing Corrosion."

Opposed Impeller Pumps

An attractive 12-page bulletin on opposed impeller pumps, suitable for boiler feed, refinery and pipe line service, has been brought out by the De Laval Steam Turbine Co. Illustrations show how opposed impellers balance axial thrust and how staggered volutes balance radial load. Dimension and capacity tables are also included for the pumps which are built in two- and four-stage designs for pressures up to 1000 psi.

Process and Safety Valves

A 4-page bulletin describes Sentry process and safety valves manufactured by the McRae Valve Corp. Cutaway views indicate the method of valve operation, including actuation for protection against fire or other emergencies. There is also a table of weights and dimensions of these valves, which may be used for shut-off purposes or as flood and dump valves.

Test Sets for Water Analyses

A 16-page brochure brought out by W. H. & L. D. Betz includes brief descriptions and photographs of testing and control equipment necessary for the more common water analyses. Titration stands, special cabinets for storing chemical-test apparatus, conductivity test sets, colorimetric comparators, and portable test sets are explained and illustrated.

Thawing Tubes

The Hauck Manufacturing Co. has issued a 4-page bulletin describing portable hopper car thawing tube equipment for use in collieries, gas and coke plants, railroads, power plants and industrial plants. Two types of equipment are illustrated, one operating with compressed air and the other with a hand pump in the fuel tank. The former burns fuel oil, kerosene or distillates, while the latter may be fired with kerosene or light furnace oil. Photographs showing the application of portable thawing equipment are also included.

Tube Expanders

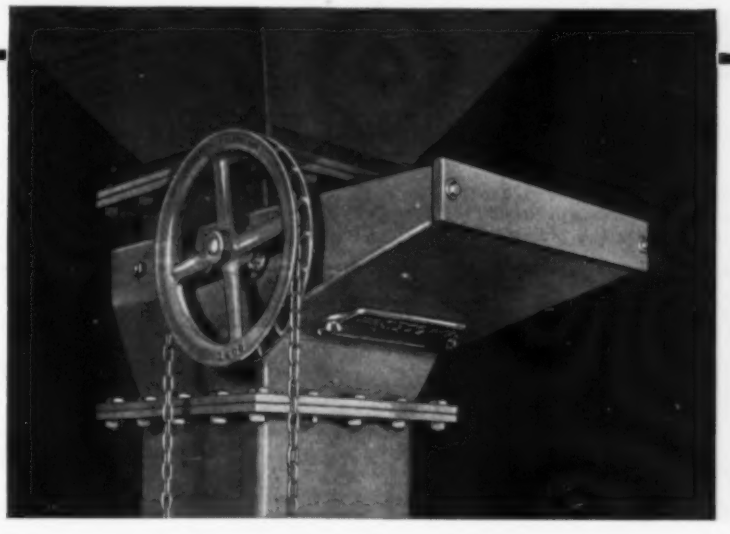
Bulletin 420, a 6-page folder that includes data on Wilson-Dudgeon tube expanders for condensers, heat-exchangers and general small tube rolling, has been made available by Thomas C. Wilson, Inc. Several different models of the expanders which incorporate an improved, adjustable ball-bearing thrust collar, are shown in cutaway sections. Tube expander accessories, heat-exchanger tube assembly and maintenance tools, and tube cleaners are also illustrated.

Metal Gaskets

An attractive 32-page catalog has been brought out by the Flexitallic Gasket Co., originators of the spiral-wound gasket. One section of the catalog discusses joint assembly design, gasket design, flange face finish, and gasket materials. Dimension tables and gasket numbers are given for styles adaptable to raised face, smooth face, vanstone and lapped joints, male and female joints, tongue and groove joints, and boiler handhole and tubecap cover assemblies. The inclusion of tables on bolting data for standard flanges, facing dimensions for standard flanges, and wall thicknesses of welded and seamless steel pipe adds to the engineering usefulness of the catalog.

Water Treatment

A 28-page bulletin entitled "The Accelerator, the Modern, Proven, High-rate Water Treating Plant" has been released by Infilco, Inc. This comprehensive account of a water-treating process begins with a history of the development of the "Accelerator" and then explains its principle of operation, distinguishing characteristics, design considerations and applications. The value of the bulletin is enhanced by the unusually fine diagrams illustrating basic principles and by informative installation photographs.



S-E-CO. COAL VALVES always operate easily because they are equipped with double racks and pinions. This design moves the gate squarely and without binding. S-E-Co. Coal Valves fit the requirements of today's modern plants.

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SPECIFY ERNST WATER COLUMNS AND GAGES FOR ALL PRESSURES AND TEMPERATURES

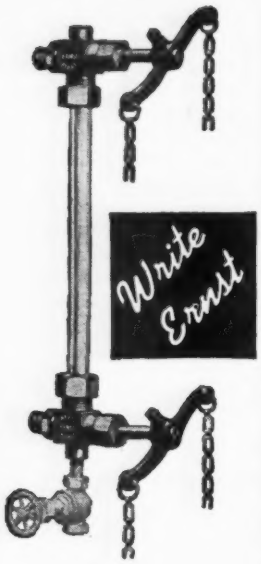

Fig. 5

Standard Vertical bronze water gage 350 pound design heavier construction up to 450 lbs., Stainless and forged steel for higher pressures.

Gages can be furnished with Automatic Ball Shut-off if required.

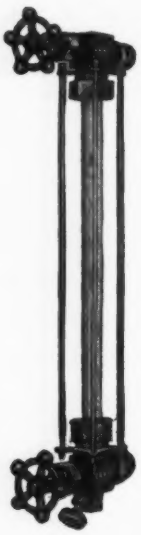

Fig. 8

All Iron gages for pressure up to 250 lbs., heavier construction up to 350 lbs.
Fig. 8SS Same fittings made in stainless steel.

Fig. 72

For steam pressure above 500 pounds we recommend ERNST Flat Gage Glass Inserts with "Split-Gland" Gages. (Write or Bulletin Q.)

INCLINED FOR BETTER VISIBILITY

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NO GAGE GLASS PACKING NUT

Simple and easy to in... a gage glass. No wre... or tools required. A ... of the hand wheel ... presses the packing...

Fig. 1

High and Low Alarm Column equipped with Split-Gland Type Adjustable Inclined Water Gage

ERNST LEAKLESS TRY COCKS

DESIGNED FOR 450-650-1500-2500 LBS.

Fig. 13

This Ernst Leakless Try Cock assures maximum safety in boilers with pressures up to 450 lbs. Disc can be replaced under full boiler pressure. Sizes: ½", ¾" or 1".

Ernst Weighted Type Try Cock

Fig. 15

250 lb. pressure bronze, with iron weight double chain pull.

Fig. 37

Insure Safety with ERNST

Mica Protected and Prismatic Reflex Inserts

Fig. 43

SIGHT FLOW INDICATORS

for insertion into pipelines

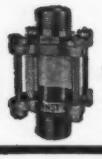

Fig. 17-28 Tubular Glass Type

Fig. E-57 Bulls Eye Type

Fig. E-811 Flapper Type

"SEE WHAT'S GOING ON" —INSIDE—

GAGE GLASS GUARDS and ILLUMINATORS

Fig. 31

GUARD AGAINST ACCIDENTS BY SPECIFYING ERNST PLASTIC SAFETY GUARDS

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Fig. 10

GAGE GLASSES—Tubular & Flat Type

High Pressure Composition Rubber Gaskets

MANUFACTURED IN ALL SIZES TO FIT YOUR WATER GAGES

Fig. 22 STANDARD RUBBER GASKET

CLEAR AND RED-LINE MAGNIFYING TYPE

FLAT TYPE REFLEX AND CLEAR

Fig. 21 LIP MOLD RUBBER GASKET

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